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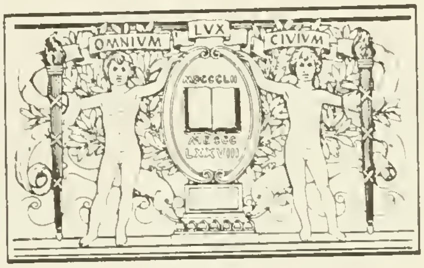

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NORTH STATION URBAN RENEWAL PROJECT

FINAL ENVIRONMENTAL IMPACT REPORT / ENVIRONMENTAL IMPACT STATEMENT

EOEA NO. 03728
HUD-ROI-EIS-83-01-F

APPENDICES

BOSTON REDEVELOPMENT AUTHORITY

NOVEMBER 30, 1983

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Appendix A NORTH STATION URBAN RENEWAL PLAN - LAND USE AND DEVELOPMENT CONTROLS

APPENDIX A

NORTH STATION URBAN RENEWAL PLAN
LAND USE AND DEVELOPMENT CONTROLS*

2.2.3 Land Use Requirements

The Redevelopment Area shall generally be devoted to residential, institutional, retail, office, parking and recreational uses. Specific uses for each parcel are set forth below. In each case, and unless specifically otherwise provided, designation of a particular use includes all accessory and ancillary uses customarily or reasonably incident to the use specified or the use of an adjoining parcel.

The specific parcels described in the controls are shown by number on Map 2.3, Development Parcels, and Map 2.4, Pedestrian Easements. These controls apply to any redevelopment of these sites whether assembled by abutters or other parties. If any of these parcels are subdivided or redeveloped in stages, the controls apply to any and all portions of the site.

2.2.3.1 Parcel 1

1. Permitted uses: Commercial or government offices, retail, public transportation facilities, parking
2. Maximum Floor Area Ratio: 10
3. Vehicular Access: From Lomasney Way
4. Design Review Required

2.2.3.2. Parcel 2

1. Permitted Uses: Public parking, public transportation facilities
2. Maximum Floor Area Ratio: 5
3. Maximum Height: 50 feet
4. Vehicular Access: from Lomasney Way
5. Design Review Required
6. Other Requirements: Easement at grade for new street and above grade for relocated Greenline elevated.

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* Preliminary revised Urban Renewal Plan Controls

2.2.3.3 Parcel 3

1. Permitted Uses: Arena, retail, public transportation facilities, parking
2. Maximum Height: 100 Feet
3. Maximum Floor Area Ratio: 5
4. Vehicular Access: From Accolon Way and Beverly Street
5. Design Review Required
6. Other Requirements: Easement at grade level for extension of existing railroad tracks; easement below grade for service road. Easement approximately 30 feet above grade for relocated Greenline elevated. Retail space fronting on public plaza and pedestrian arcade at grade.

2.2.3.4 Parcel 4

1. Permitted Uses: Office, hotel and retail
2. Maximum Height: 200 feet
3. Maximum Floor Area Ratio: 10
4. Vehicular Access: Accolon Way
5. Design Review Required
6. Other Requirements: At grade retail space frontage on Causeway Street and public plaza.

2.2.3.5 Parcel 5

1. Permitted Uses: Public plaza and pedestrian ways
2. Design Review Required

2.2.3.6 Parcel 6

1. Permitted Uses: Hotel, retail, parking, office and residential
2. Maximum Height: 200'
3. Maximum Floor Area Ratio: 5
4. Vehicular Access: From New Street & Beverly Street
5. Other requirements: Minimum set-back from river of 50 feet for pedestrian easement; landscaping of riveredge easement to include a continuation of existing esplanade pedestrian and bicycle paths with direct connection to

existing paths and to the landscaped area at the southern end of the MDC dam; pedestrian easement at all pedestrian levels of 50 foot minimum width connecting river edge pedestrian easement through Parcel 6 to Parcel 5.

2.2.3.7 Parcel 7

1. Permitted Uses: Residential, retail and parking.

2. Maximum Height: 150 feet

3. Maximum Floor Area Ratio: 5

4. Vehicular access: From New Street and Beverly Street

5. Other requirements: Pedestrian easement of 50 feet minimum width along water edge at north side of island with connections to mainland public river edge pedestrian easement across channel at West End, and to both river edge easement and Parcel 5 north-south easement across channel at east end.

2.2.3.8 Parcel 8

1. Permitted Uses: Museum, Public exhibit, ancillary retail, parking, public open space

2. Maximum Height: 100'

3. Maximum Floor Area Ratio: 5

4. Vehicular Access: From New Street and Beverly Street

5. Other requirements: Pedestrian access from east side of Parcel 5 pedestrian easement.

NORTH STATION REDEVELOPMENT PROJECT

DEVELOPMENT PARCELS

BOSTON REDEVELOPMENT AUTHORITY

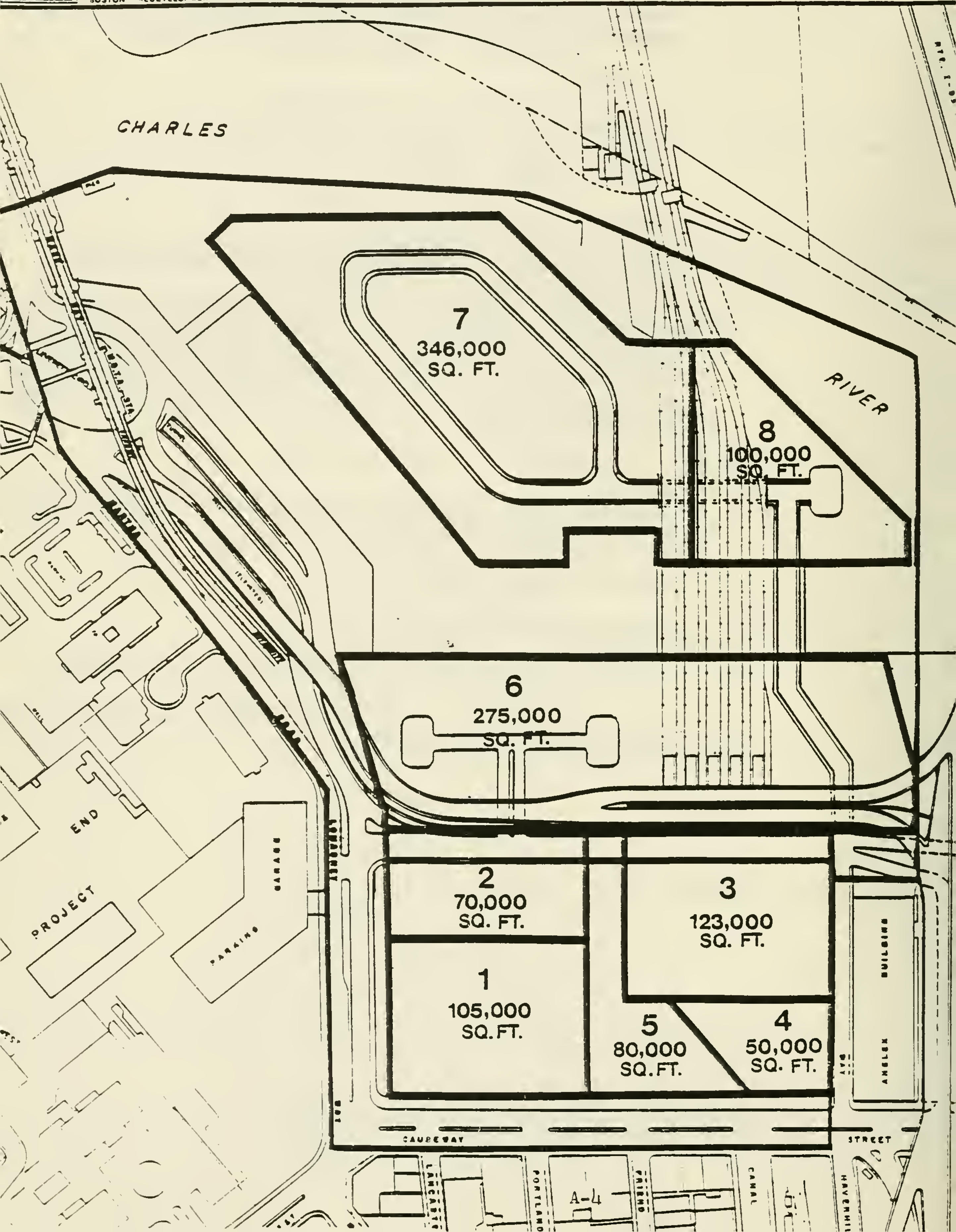


Figure A-1

Appendix B ALTERNATE SITE PLANS FOR NEW ARENA

Alternate Site Plans

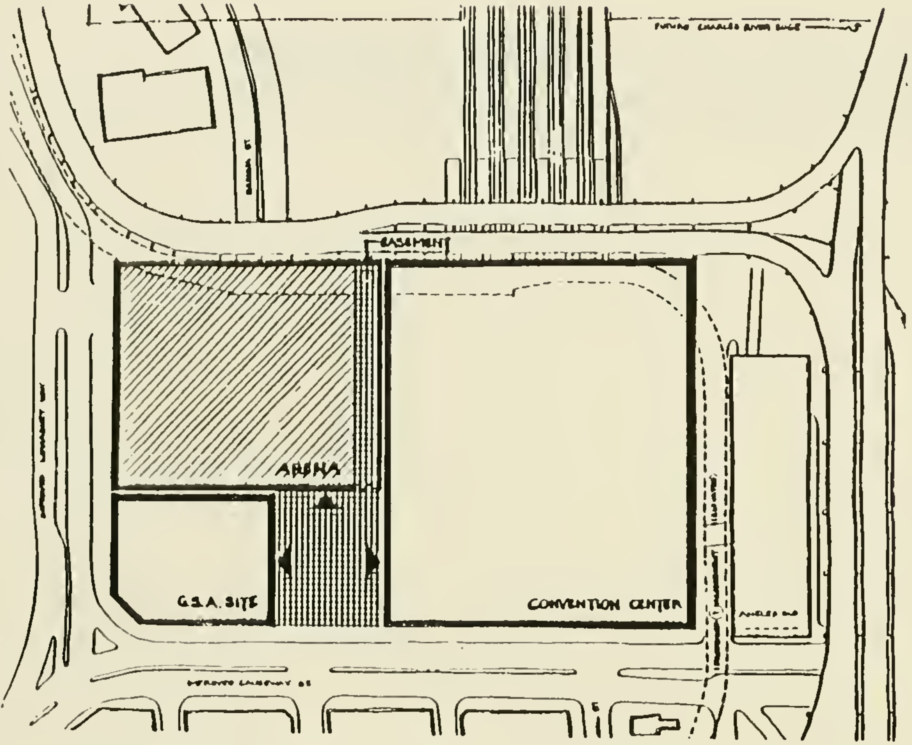
Prior to focusing on the site behind the Garden, several options for locating the arena were examined and discussed with the BRA, representatives of the GSA, the architects for the GSA, and members of the arena committee.

The two schemes discussed in this report are variations of option C.

Of the other options considered, option E stimulated the most interest. It suggested moving the GSA site behind the Garden, and building an arena on the site designated for the GSA. This arrangement of the GSA as a major landmark on axis with Canal Street, and of a plaza on the current Garden site as a focus for the North Station area, is an intriguing urban design scheme. However, it requires complex and precise phasing of development and commitment to demolish the Garden by the time the GSA building is completed.

Source: Moshe Safdie and Associates, Inc., North Station Development Plan: A New Arena - Preliminary Report, prepared for Boston Redevelopment Authority, May 1981.

Option A



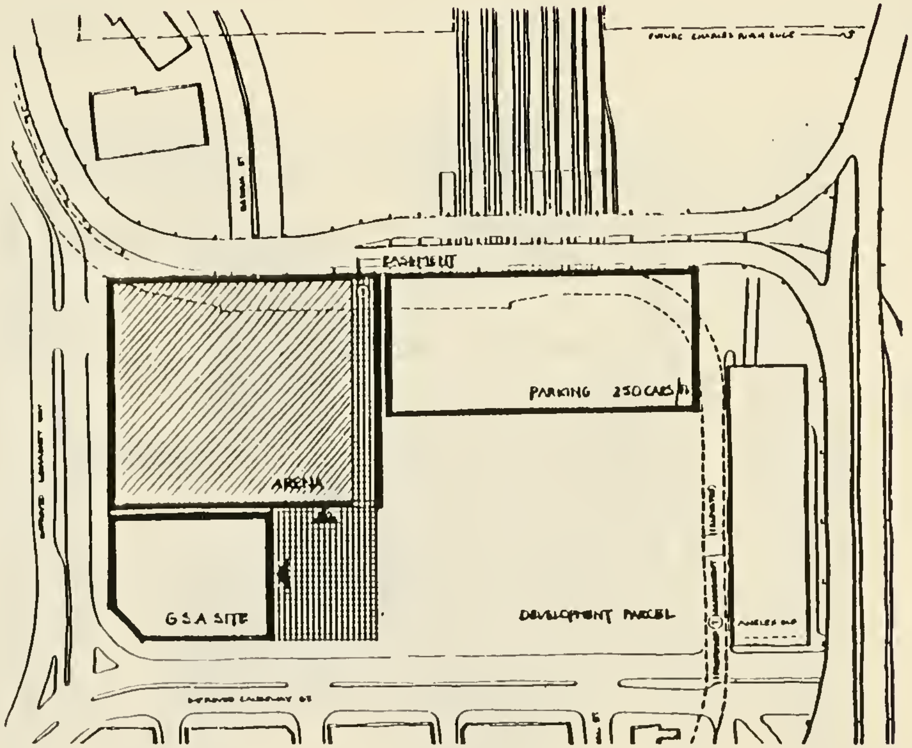
Advantages

- Maximum development: arena and convention center possible.
- Arena can be built while Garden remains in operation.
- Separate construction schedules for arena, convention center, and GSA possible.
- No air rights construction necessary.
- A common plaza with direct access to all three facilities.
- Green Line effectively screened by arena and convention center.

Constraints

- GSA site significantly reduced in size, and therefore also building configuration options.
- Poor physical relationship between arena and GSA.
- No space available for parking in Sub-Area 1, only north of expressway ramps.
- Commuter tracks cannot be extended since convention center needs to be at grade.

Option B



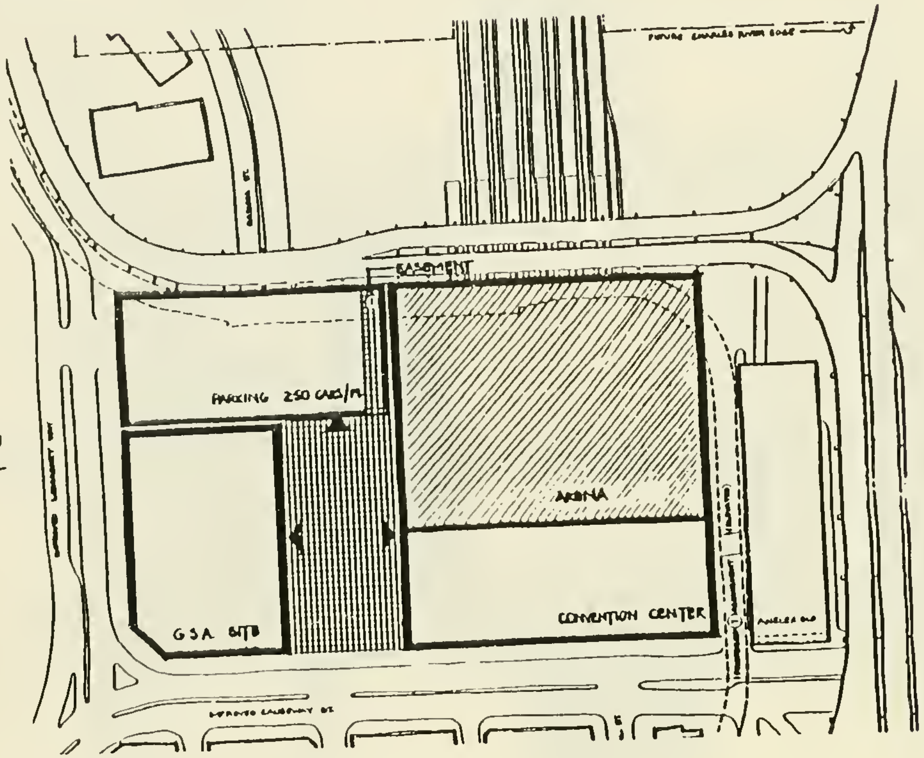
Advantages

- Arena can be built while Garden remains in operation.
- Parking accomodated on site.
- Commuter tracks can be extended (beneath the garage).
- Major development parcel along Causeway Street once the Garden is removed.
- Green Line effectively screened by arena and parking.

Constraints

- GSA site significantly reduced in size.
- Poor physical relationship between arena and GSA.
- No provision for convention/exhibition center.

Option C



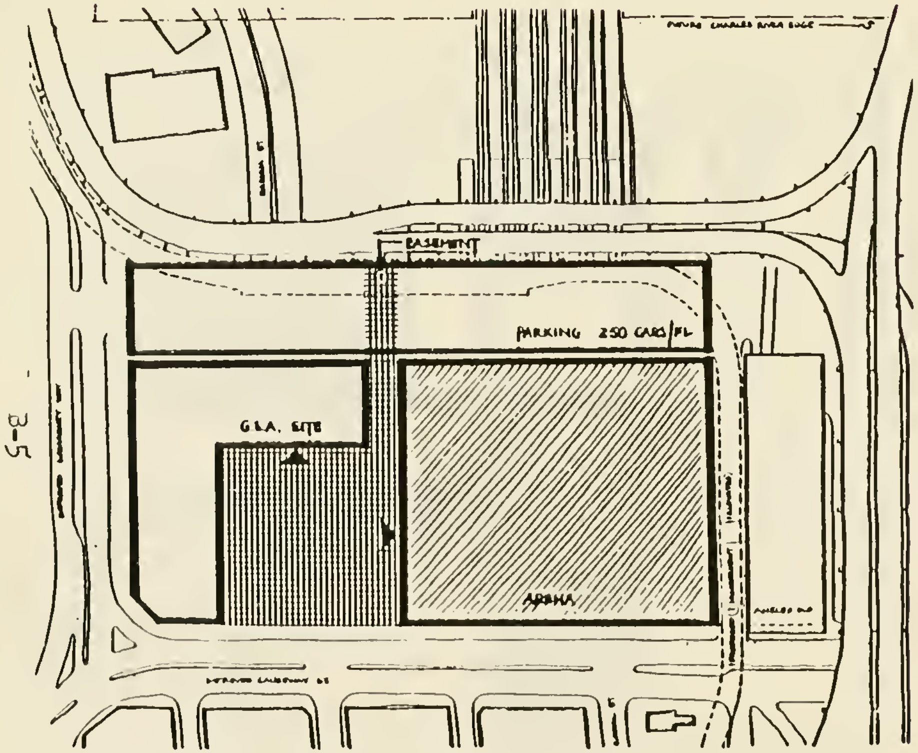
Advantages

- Maximum development: arena and convention center possible.
- Arena can be built (along with the first phase of the convention center) while the Garden remains in operation.
- Parking accomodated on site.
- GSA site not significantly reduced.
- Major development parcel (or the remainder of the convention center) along Causeway Street once the Garden is removed.
- Green Line effectively covered by arena and parking.

Constraints

- Convention Center and possibly arena requiring a two phase construction.
- Convention center beneath the arena precludes the possibility of extending commuter tracks.
- Premiums of air rights construction.

Option D



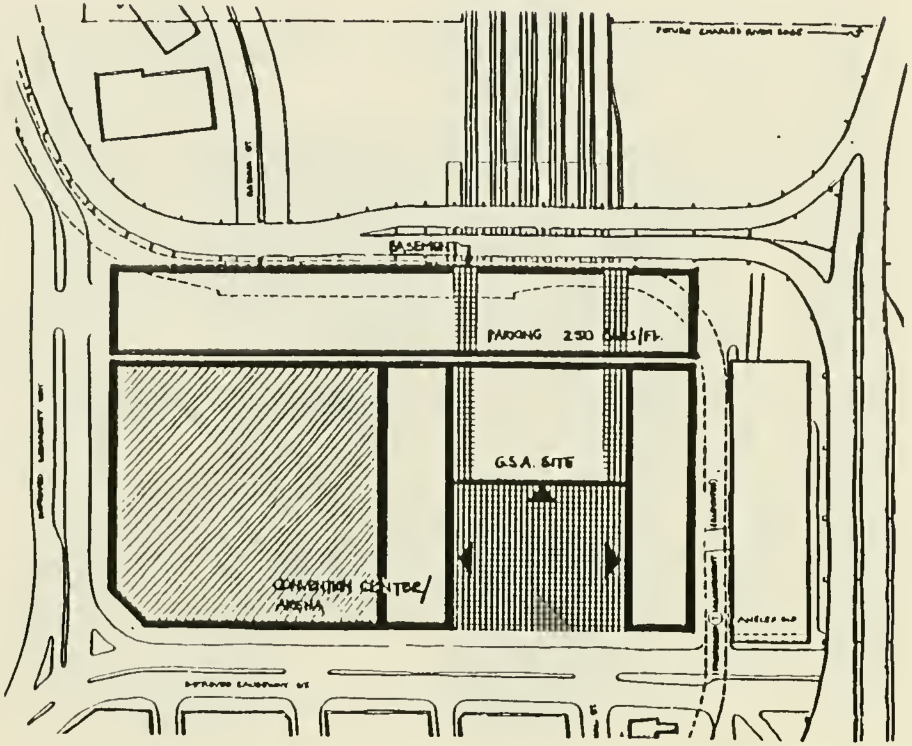
Advantages

- Arena size and capacity not restricted by a narrow site.
- GSA site not significantly reduced.
- Parking accomodated on site.
- Green Line incorporated into parking structure.
- Commuter tracks can be extended (beneath the garage).

Constraints

- Garden has to be removed before a new arena can be built.
- No provision for convention center.

Option E



Advantages

- Maximum development: arena and convention center possible.
- Arena can be built while Garden remains in operation.
- Parking accomodated on site.
- Commuter tracks can be extended (beneath the garage).
- Green Line effectively screened by parking.
- Prominent location for GSA site, on axis of Canal Street.
- Major open space at end of Canal Street as a focus for the North Station area and a setting for GSA.
- Arena size and capacity not restricted by small site.

Constraints

- Relocation of GSA site involves administrative complexities and likely delay of project.
- A commitment for the demolition of the Garden by a completion date of GSA is required.

Appendix C FINDINGS AND RECOMMENDATIONS OF THE ARENA COMMITTEE

FINDINGS AND RECOMMENDATIONS OF THE ARENA COMMITTEE*

INTRODUCTION

Massachusetts' arena, convention and tourism needs are the focus of the comprehensive plan the Arena Committee is announcing today. The proposals are the result of five months of intensive study, ten formal Committee meetings, countless hours of work by Committee members and extensive consultations with financial, legal, architectural, engineering and construction experts.

The Committee offers two sets of recommendations. The first proposes the construction of a home for professional sports and entertainment events in the Greater Boston area. The second seeks to increase the revenues produced by convention and tourist business across the State, and to provide financial support to the State's Regional Convention and Tourist Bureaus. Costs have been targeted for payment by out-of-state visitors and those who use convention and arena facilities. The benefits are realized in the creation of new jobs, the retention of present jobs, the expansion of business opportunities and the generation of new state and local revenues. If these recommendations are not pursued, Massachusetts will face the loss of badly needed revenues and business amounting to millions of dollars.

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* Source: The Arena Committee, Final Recommendations, August 1981, pp. 6, 11-12, 15-16, 18.

Arena-Related Recommendations

1) Enact legislation to establish an Arena Authority. The Arena Authority would be empowered to finance, construct and hire expert management to operate the arena and related parking facilities.
2) Build a new 16,000 seat arena behind the existing Boston Garden. Construct two parking facilities - one a 1,000 car facility to the rear of the GSA federal building site and the other, a 500 car facility located on two levels beneath the new arena.
3) Increase the hotel tax from 5.7% to 8% statewide with most of this increase going into the State's General Revenue Fund and a small portion used to help meet the State's arena, convention and tourism needs.
4) Pledge the hotel tax increase within the Route 495 area to back the bonds sold to finance the arena. (As previously stated, this portion of the tax would be earmarked to provide additional security for the arena bonds resulting in a better bond rating and a lower interest cost. Based on the 1981 existing number of hotel rooms and room rates, increasing the hotel tax from 5.7% to 8% will generate approximately $5.3 million within Route 495. The major portion of these revenues would be used by the State as general revenues. It is estimated that only a small portion would be applied to make payments on the arena bonds.)

Tourism and Convention Recommendations

1) Establish a tourism promotion and municipal convention operations aid program. The program would be administered by the State and funded by a portion of the hotel tax. The Committee recommends that one-tenth of the hotel tax collected statewide in the base year of fiscal 1981 be the initial level of funding for this program. In succeeding fiscal years, the amount of each allocation would increase by 10%. Two-thirds of the fund would be allocated to a tourism promotion program with distribution at the discretion of the State. The remaining one-third of the fund would also be distributed by the State to eligible communities to help defray the operating costs of municipal convention and auditorium facilities.

2) Modernize and expand the Hynes Auditorium. The expansion of meeting room and exhibition space would occur on the City-owned portion of the Ring Road and the Prudential commercial block C. The total preliminary estimated cost of this project is $25 million with $7 million for modernization and $18 million for expansion.

3) Replenish the existing State Convention Fund, currently at $7.4 million, to provide the 70% State share of the Hynes expansion and modernization cost with the City of Boston contributing the balance of funds needed.

SUMMARY OF THE ARENA COMMITTEE PROPOSAL

Below are the seven principal proposals of the Arena Committee. The first five require legislation and are included in the Bill the Committee is making public today. The sixth proposal, to pursue an expansion of Hynes, is a recommendation which does not require legislation. The seventh proposal is a recommendation which would require changes in existing legislation.

1. ESTABLISH AN ARENA AUTHORITY with powers to build, finance, own and operate the multi-purpose arena and related parking facilities.

2. BUILD A NEW 16,000 SEAT ARENA on a site behind the existing Boston Garden. Construct a total of 1,500 parking spaces adjacent to and in conjunction with the Arena.

3. INCREASE THE HOTEL (ROOM OCCUPANCY) TAX STATEWIDE BY 2.3% from 5.7% to 8.0% to address arena, convention and tourism promotion needs with the bulk of the hotel tax funds going to the State as general revenues.

4. PLEDGE THE HOTEL TAX INCREASE WITHIN THE ROUTE I-495 AREA to back the bonds sold to finance the construction of the Arena. Finance the parking facilities through bonds backed by parking revenues.

5. ESTABLISH A TOURISM AND CONVENTION FUND with an annual allocation (one-tenth of the room occupancy tax statewide in a base year of 1981 to be the initial level of funding) to be used to promote tourism and to help defray the operating costs of municipally-owned convention and auditorium facilities.

6. PURSUE AN EXPANSION AND MODERNIZATION OF HYNES AUDITORIUM by expanding onto the City-owned portion of the Ring Road and into Prudential commercial block C.

7. REPLENISH THE COMMONWEALTH'S EXISTING CONVENTION FUND to provide the 70% State share of the Hynes expansion and modernization cost with the City of Boston contributing the balance of funds needed.

Appendix D COMMONWEALTH OF MASSACHUSETTS WATER QUALITY STANDARDS (EXCERPTS)

Excerpts From:

Commonwealth of Massachusetts

Water Resources Commission

Division of Water Pollution Control

WATER QUALITY STANDARDS

PART 3 MINIMUM WATER QUALITY CRITERIA AND ASSOCIATED USES

Regulation 3.1 Description of Contents. This part sets forth the Classes to be used by the Division in classifying the waters of the Commonwealth according to the uses for which the waters shall be enhanced, maintained and protected. For each class, the most sensitive beneficial uses are identified and minimum criteria for water quality in the water column are established. The minimum criteria in Reg. 3.4 have been developed by applying the criteria contained in the EPA publication Quality Criteria for Water (EPA-440/9-76-023) to account for local conditions including, but not limited to:

a) The characteristics of the biological community

b) Temperature, weather and flow characteristics, and

c) Synergistic and antagonistic effects of combinations of pollutants.

Regulation 3.2 Coordination with Federal Criteria. The Division will use the EPA publication entitled Quality Criteria for Water, EPA-440/9-76-023 as guidance in establishing case-by-case discharge limits for pollutants not specifically listed in these standards but included under the heading "Other Constituents" in Regulation 3.4, for identifying bioassay application factors and for interpretations of narrative criteria. Where the minimum criteria specifically listed by the Division in this part differ from those contained in the federal criteria, the provisions of the specifically listed criteria in these standards shall apply.

Regulation 3.3 Classes and Designated Uses. The waters of the Commonwealth will be assigned to one of the classes listed below. Each class is defined by the most sensitive, and therefore governing, uses which it is intended to protect. The classes are:

Classes for Inland Waters

Class A - Waters assigned to this class are designated for use as a source of public water supply.

Class B - Waters assigned to this class are designated for the uses of protection and propagation of fish, other aquatic life and wildlife; and for primary and secondary contact recreation.

Class C - Waters assigned to this class are designated for the uses of protection and propagation of fish, other aquatic life and wildlife; and for secondary contact recreation.

Classes for Coastal and Marine Waters

Class SA - Waters assigned to this class are designated for the uses of protection and propagation of fish, other aquatic life and wildlife; for primary and secondary contact recreation; and for shellfish harvesting without depuration in approved areas.

Class SB - Waters assigned to this class are designated for the uses of protection and propagation of fish, other aquatic life and wildlife; for primary and secondary contact recreation; and for shellfish harvesting with depuration (Restricted Shellfish Areas).

Class SC - Waters assigned to this class are designated for the protection and propagation of fish, other aquatic life and wildlife; and for secondary contact recreation.

Regulation 3.4 Minimum Criteria. The following minimum criteria are adopted and shall be applicable to all waters of the Commonwealth.

A. These minimum criteria are applicable to all waters of the Commonwealth, unless criteria specified for individual classes are more stringent.

Parameter	Criteria
1. Aesthetics	All waters shall be free from pollutants in concentrations or combinations that: a) Settle to form objectionable deposits; b) Float as debris, scum or other matter to form nuisances; c) Produce objectionable odor, color, taste or turbidity; or d) Result in the dominance of nuisance species.

2. Radioactive Substances	Shall not exceed the recommended limits of the United States Enviornmental Protection Agency's National Drinking Water Regulations.
3. Tainting Substances	Shall not be in concentrations or combinations that produce undesirable flavors in the edible portions of aquatic organisms.
4. Color, Turbidity, Total Suspended Solids	Shall not be in concentrations or combinations that would exceed the recommended limits on the most sensitive receiving water use.
5. Oil and Grease	The water surface shall be free from floating oils, grease and petrochemicals and any concentrations or combinations in the water column or sediments that are aesthetically objectionable or deleterious to the biota are prohibited. For oil and grease of petroleum origin the maximum allowable discharge concentration is 15 mg/l.
6. Nutrients	Shall not exceed the site-specific limits necessary to control accelerated or cultural eutrophication.
7. Other Constituents	Waters shall be free from pollutants in concentrations or combinations that a) Exceed the recommended limits on the most sensitive receiving water use; b) Injure, are toxic to, or produce adverse physiological or behavioral responses in humans or aquatic life; or c) Exceed site-specific safe exposure levels determined by bioassay using sensitive resident species.

B. Inland Waters - the following additional minimum criteria are applicalbe to inland water classifications.

For Class C waters:

Parameter	Criteria
1. Dissolved Oxygen	Shall be a minimum of 5.0 mg/l in warm water fisheries and a minimum of 6.0 mg/l in cold water fisheries.
2. Temperature	Shall not exceed 83°F (28.3°c) in warm water fisheries or 68°F (20°c) in cold water fisheries, nor shall the rise resulting from artificial origin exceed 4.0°F (2.2°c).

3. pH	Shall be in the range of 6.5-9.0 standard units and not more than 0.2 units outside of the naturally occurring range.
4. Fecal Coliform Bacteria	Shall not exceed a log mean for a set of samples of 1000 per 100 ml, nor shall more than 10% of the total samples exceed 2,500 per 100 ml during any monthly sampling period, except as provided in Regulation 2.1.

Appendix E SOURCES AND EFFECTS OF MAJOR AIR POLLUTANTS

APPENDIX E: SOURCES AND EFFECTS OF MAJOR AIR POLLUTANTS

Carbon Monoxide (CO)

CO is a toxic, colorless, and odorless gas. Its toxicity arises from its affinity for combining with the hemoglobin in the blood, preventing the transport of oxygen. Low level exposu of a few hours can result in temporary impairment of human psychomotor functions. At higher exposure levels, headaches, nausea, and convulsion can occur.

CO is formed from incomplete combustion of organic material used as fuels. All of the power plants in transportation that use fossil fuels (for example, gasoline, diesel fuel, jet fuel, and propane) produce CO in their exhaust emissions. The gasoline-powered automobile is a very significant source of CO. In Boston, for example, gasoline-powered vehicles are responsibl for 98% of CO emissions from all transportation sources, and 95% of all CO emissions in the Metropolitan Boston area. CO emission in the exhaust increases very rapidly when the engine is operated at air-to-fuel ratios below stoichiometric (i.e., too fuel-rich).

Oxides of Nitrogen (NO_x)

Of the approximately 8 oxides of nitrogen that are found in the atmosphere, only nitric oxide (NO) and nitrogen dioxide (NO_2) are of significance from an air pollution standpoint. NO is a colorless and odorless gas. The biologic toxicity of NO is low and consequently NO is not considered a health hazard. NO_2, on the other hand, is a toxic gas. Low concentrations of NO_2 can produce eye and nose irritation.

With higher daily dosages of NO_2, epidemiological studies have suggested a higher incidence of chronic bronchitis and pneumoniti

Most of the NO_x produced in combustion processes is initiall in the form of NO. NO formation is favored at high temperatures that are normally encountered in the combustion chamber. Because of the chemical kinetics involved, NO continues to be the principal oxide in the exhaust gases. Since NO is an index of engine operating efficiency, high NO emissions are associated with combustion taking place at stoichiometric ratios. Gas turbine engines operating at high power settings and diesel engines are the two principal types of power plants that emit significant amounts of NO. The principal source of NO_2 in the atmosphere is the oxidation of NO. NO_x is involved in photochemical reactions and represents a significant source of photochemical oxidant precursors. In the Boston area, diesel- and gasoline-powered vehicles contribute respectively 13% and 85% of the total NO_x emissions from all transportation sources, and 6% and 39% of all NO_x emissions in Metropolitan Boston.

NO_x is generally a transportation-related pollutant. Emissions of NO_x from the transportation sector are expected to increase because current control strategies concentrate more on HC and CO, because available control technology for NO_x is not very well developed, and because there is increasing demand for the diesel powerplant in automotive use.

Hydrocarbons (HC)

The HC that are of concern are the nonmethane, or reactive, types including the olefins, ketones, alcohol, organic acids, and chlorinated HC. At levels that are typically found in ambient urban atmospheres, there are no known health effects that can be attributed directly to gaseous HC. However, reactive HC play a dominant role in photochemical oxidant formation.

Because of the volatility of the fuels, such as gasoline, the emissions from a motor vehicle can originate from the engine exhaust (representing mostly incomplete combustion products), the crankcase, the carburetor, and the fuel tank. About 60% of the emissions from a gasoline-powered vehicle come from the exhaust. Since exhaust HC is a good indicator of engine operating inefficiency, we find exhaust HC to be at a minimum when the engine is operated near stoichiometric conditions. Crankcase emissions result from blowby past the piston rings. The vaporization of the fuel during "hot soak" condition after engine shutdown will result in HC emissions from the carburetor. Fuel vaporization from the tank takes place because of temperature and/or barometric pressure changes. Gasoline-powered vehicles in the Boston area contribute up to 89% of the HC emissions from all transportation sources and 55% of the emissions from the Metropolitan Boston area.

Ozone

Ozone is the principal constituent of a class of pollutants called photochemical oxidants. These include natural ozone (formed from natural hydrocarbon sources or injected from the stratosphere) and the products of photochemical reactions from oxidant precursors such as HC and NO_x. Ozone can cause respiratory and eye irritation. People with asthmatic conditions are especially vulnerable to ozone.

Ozone is a "secondary" pollutant. It is not discharged directly into the atmosphere, but instead represents the product of photochemical reactions of HC and NO_x emissions from transportation and nontransportation sources. For significant ozone to be formed in the atmosphere, high concentrations of precursors and intense solar radiation are necessary. The formation of ozone may be visualized (in simplified terms) as a three stage process: the depletion of the precursor pollutants such as NO and reactive HC; the creation of an intermediate product, such as NO_2; and the depletion of the intermediate product and the formation of ozone. The need for intense solar radiation in these reactions explains why high ozone levels are only found in the summer months and not in the winter. Because ozone is not emitted directly into the atmosphere, it is not feasible to associate ozone levels with emission source contributions directly.

Lead

Lead in the ambient atmosphere is generally carried by particulates or aerosols. However, in smaller concentrations, lead can occur in the form of organic gases. Lead is a toxic substance and its ingestion is cumulative in the human body. It primarily affects the red blood cells, the nervous system, certain soft tissues, and bone. Its adverse health effects range from mild anemia to severe neurobehavioral impairment.

Combustion of waste oil, incineration of solid waste, mining and smelting of lead represent some of the major stationary sources of lead emissions. By far, however, the most significant source of airborne lead is exhaust emissions from gasoline-powered motor vehicles. The lead is used in gasoline as an antiknock additive. The additive in the form of tetraethyl or tetramethyl lead is converted to lead oxide in the combustion chamber. The oxide acts to inhibit lead halides. The halides are exhausted in the form of aerosol. On a nationwide basis, gasoline-powered automobiles are responsible for about 88% of the lead emissions. Contributions from other transportation sources are quite insignificant.

Suspended Particulates

This category of pollutants can exist both in dry phase, such as dust or fumes, and in a liquid phase, such as aerosols. Suspended particulate matter in the respiratory tract can cause injury by itself, or it can promote the toxic effects of certain other pollutants. Suspended particulate matter in the ambient atmosphere reduces visibility, changes absorption of radiation, and participates in photochemical reactions.

Emission of particulate matter into the atmosphere arises from industrial processes, fuel combustion, construction operations, agricultural activities, and natural origins such as wind erosion and the release of terpenes (a reactive hydrocarbon) from evergreens. Transportation sources emit particulate matter in two principal means: as aerosols in the exhaust, and as tire wear. On unpaved roads or dirty surfaces, tires from the moving vehicle will pulverize the soil and other surface materials and make the small particles airborne by entrainment. In a metropolitan area such as Boston, transportation sources are estimated to contribute approximately 28% of the total emissions of particulate matter. Combustion sources are responsible for an estimated 58% of the total emisisons.

Oxides of Sulfur (SO_x)

The oxides that are of primary concern are sulfur dioxide (SO_2) and the sulfates. SO_2 is generally an irritant of the upper respiratory tract, but when absorbed onto other particulat matter, it can be carried deep into the lungs where greater injury can result. In the atmosphere, SO_2 will oxidize and hydrolyze to form sulfuric acid and sulfate aerosols. Recent studies suggest that sulfates are more likely than SO_2 alone to be responsible for many of the adverse health effects typically associated with oxides of sulfur.

SO_2 is formed from combustion of any sulfur-bearing fuel, from many industrial processes, and from incineration. Sulfur is present in the fuel as an impurity. Fuel combustion associated with electric generation, industrial and commercial uses and residential heating is responsible for over 90% of all emissions of SO_x. In the Boston metropolitan area, transportation sources contribute only about 3% of the SO_x emissions. Gasoline-powered automobiles equipped with catalytic converters produce SO_x emissions mostly in the form of the more toxic submicron sulfuric acid aerosols. However, since contribution from the automobile is typically less than 2% of the total SO_x emissions, present control strategies as contained in state implementation plans are still directed primarily at stationary sources.

Source: Bolt Beranek and Newman, Inc., Air Quality and Noise Impact Analyses of the North Station Urban Renewal Project (K. M. Chng et al.), Report No. 4477, Cambridge, May 1982, Appendix B.

Appendix F AIR QUALITY MONITORING PROGRAM AT NORTH STATION

APPENDIX F: AIR QUALITY MONITORING PROGRAM AT NORTH STATION*

F.1 Objective and Scope

The purpose of the field measurement program was to better define the existing ambient air quality in the North Station area and selected traffic intersections in the vicinity. We measured ambient carbon monoxide (CO) at one site on a continuous basis. Measurements at each of the traffic intersections (satellite monitors) were made one day per month during the three months of monitoring.

F.2 Site Selection

The stationary CO site was located at 133 Causeway Street across from North Station. This site is centrally located in the area, borders the proposed project area, and represents an area of high public exposure. We also placed a second CO monitor at the site to measure on alternate days at a higher level to determine the mixing and containment effects that result from the elevated structure present in that area.

The site and continuous sampling probe were selected in accordance with established U.S. Environmental guidelines. We also involved the Massachusetts Department of Environmental Quality Engineering (DEQE) in the site selection process.

The wind monitoring site was located on the roof of 133 Causeway Street. This particular site was chosen to measure areawide wind direction and speed. The rooftop site was also chosen in an attempt to eliminate "channeling" effects on wind behavior resulting from structures in the area.

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* Source: Bolt Beranek and Newman, Inc., Air Quality and Noise Impact Analyses of the North Station Urban Renewal Project (K. M. Chng et al.), Report No. 4477, Cambridge, May 1982, Appendix D.

The satellite monitoring phase of the measurement program occurred for one day per month. Four selected intersections were measured at three positions during the day of the monitoring. The intersections were chosen by DEQE and BRA as traffic impact areas. The locations of the continuous NDIR site and all of the satellite CO sites are shown in Fig. I-1.

F.3 Measurement Methods

The instrument used for continuous monitoring was a Beckman 865 infrared analyzer with a programmable automatic zero and span module. The Beckman 865 uses a nondispersive infrared (NDIR) method. This NDIR method is an EPA-referenced method for measuring CO. The ecolyzers used for sampling on alternate days at 133 Causeway Street and for the satellite monitoring program use an electrochemical method for the detection of CO. All CO monitors were used in conjunction with stripchart recorders that depicted concentration data on a continuous basis.

For the measurements of wind speed and wind direction, we used a Climatronics Electronic Weather Station that recorded concurrently both wind speed and direction data on a continuous basis on a stripchart recorder.

F.4 Quality Assurance Procedures

The Beckman analyzer was serviced and checked at BBN's laboratory before installation at the monitoring site. The Beckman analyzer was programmed for automatic zero and span calibration checks every 6 hr. A 44-ppm span gas from Scientific Gas was used for the span check.

The measurement program was designed to follow the EPA guidelines for Prevention of Significant Deterioration (PSD) to ensure accuracy and reliability. To meet the requirements of these guidelines a calibration of the Beckman analyzer was performed by the DEQE on 10 July 1980. The calibration gases used were provided by DEQE and are traceable to National Bureau of Standards reference gases. The calibration revealed that the analyzer readings were about 6.6% higher at 6.5 ppm and 2.9% higher at 42.5 ppm. Also, in accordance with PSD guidelines, weekly precision checks of the Beckman analyzer were performed using a 9.2-ppm gas provided by the DEQE. The percentage differences ranged from -7.6% to 0% with an average of -2.3%. The standard deviation for these 9 checks was estimated at 2.2%. Consequently, the lower 95% and upper 95% limits of the precision checks were estimated at -6.6% and 2.0%. An audit of the analyzer accuracy was performed on October 14, 1980, using the following NBS traceable gases provided by DEQE - 41.3, 18.6, 9.2, and 6.1 ppm. The percentage differences ranged from -12.8% to 6.6%, with an average of -2.6%. The high percentage difference resulted from the 41.3 ppm audit gas. The pressure in the tank was very low. The analyzer performance at this range is not considered representative due to the problems with this audit gas. If this audit point were eliminated, the percentage differences would range from -3.3% to 6.6%, with an average of 0.7%. The standard deviation was estimated at 5.1%. Consequently, the lower 95% and upper 95% limits of the audit tests were estimated at -9.3% and +10.8%, respectively.

To ensure the accuracy of the ecolyzers being used in this program, a thorough check-out and testing was performed at BBN's lab before installation.

The ecolyzer that was used to monitor CO on alternate days at 133 Causeway Street was calibrated at the beginning and end of its measurement period. The ecolyzers used in the satellite monitoring program were calibrated on a schedule of at least once every 4 hr to ensure their stability and reliability.

BBN technicians serviced the 133 Causeway Street site routinely on alternate days. During these visits, manual checks of all equipment, electrical and plumbing connections, supplies, and zero and span checks were made and recorded on log sheets.

During the satellite monitoring phase, BBN technicians were present for the entire length of the measurement period to ensure proper equipment performance.

N.B.: Field measurements results, including hourly monitoring data, are included in Appendix E of BBN Report No. 4477. Copies of the full report are available to reviewing agencies and individuals upon request.

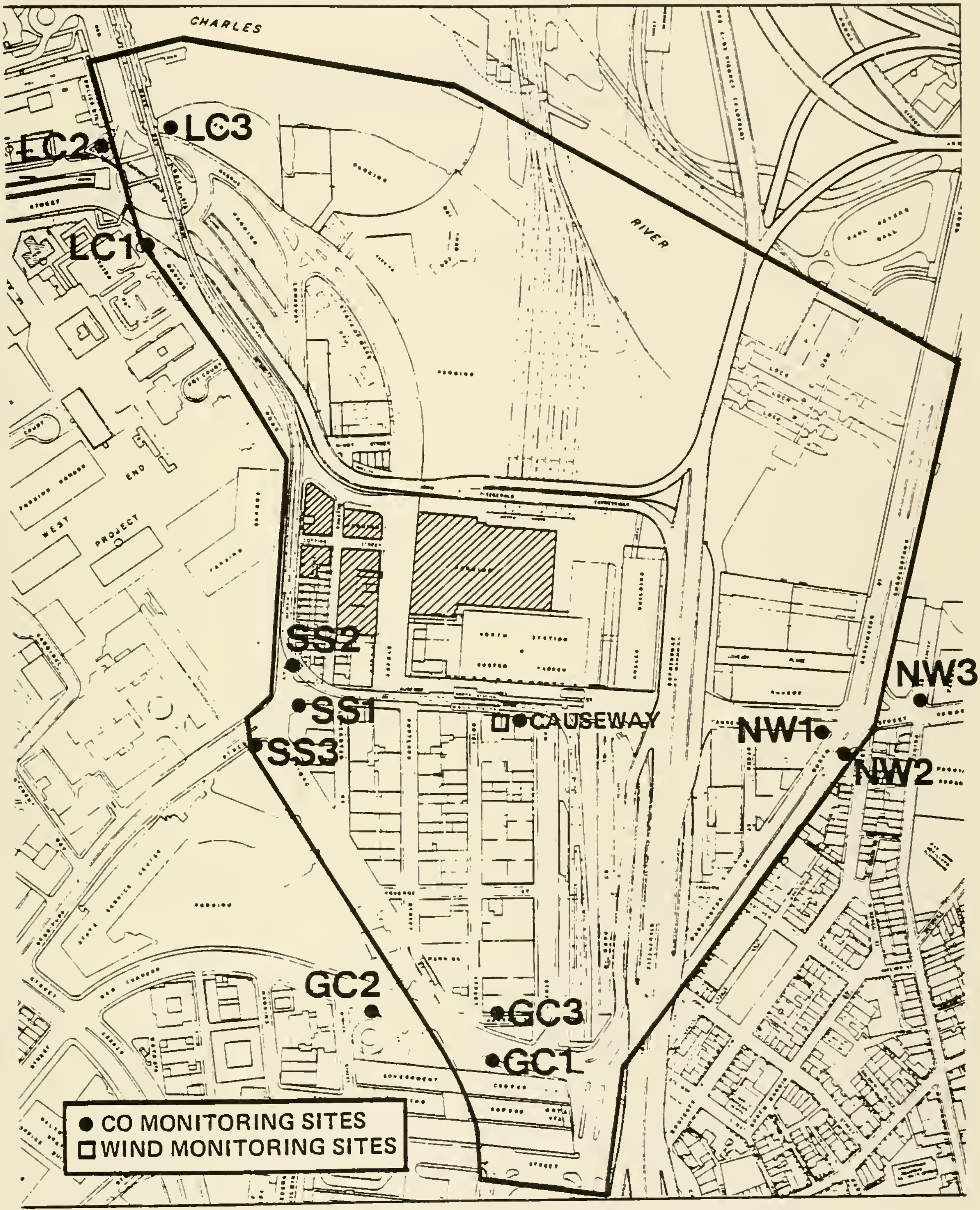

FIG. I-1. PROJECT AREA SHOWING CARBON MONOXIDE AND WIND MEASUREMENT LOCATIONS.

Appendix G METHODOLOGY AND ASSUMPTIONS FOR NOISE LEVEL COMPUTATIONS

1. North Station Project Area Analysis
2. North Station Green Line Alternatives Analysis

APPENDIX G-1: NOISE LEVEL COMPUTATIONS
(North Station Urban Renewal Project)

Methods

Day-night sound levels were computed for each sensitive location. Each location is affected by the noise of several sources, i.e., city streets, expressway mainline and ramps, the Green Line, and the commuter rail line. The day-night sound level produced by each source was computed for a reference distance and then adjusted by the actual distance to each noise-sensitive location. Shielding effects of buildings were also included. The following equations were used to compute the reference distance day-night sound levels:

$$L_{dn} = EL + 10 \log \frac{1}{24} \left[(15)10^{\frac{L_d}{10}} + (9)10^{\frac{L_n+10}{10}} \right] ,$$

where L_d is the average daytime equivalent sound level, and L_n is the average nighttime equivalent sound level. In turn

$$L_d = EL + 10 \log \frac{V_d}{SD} + 1.7^*$$

$$L_n = EL + 10 \log \frac{V_n}{SD} + 1.7 \quad ,$$

where EL is Emission Level, the A-weighted sound level produced by the noise source in question as measured at 50 ft; V_d is the number of vehicles (noise sources) passing per average daytime hour; V_n is the number of vehicles (noise sources) passing by per average nighttime hour; S is the speed at which noise sources pass by, and D is the reference distance, which is 50 ft. The following paragraphs give EL and S for each noise source and explain how V is determined.

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*See User's Manual: FHWA Level 2 Highway Traffic Noise Predicted Model. STAMINA 1.0, FHWA-RD-78-138.

Source: Bolt Beranek and Newman, Inc., Air Quality and Noise Impact Analyses of the North Station Urban Renewal Project (K. M. Chng et al.), Report No. 4477, Cambridge, May 1982, Appendix F.

Emission Levels (EL)

Noise Source	Emission Level, dBA at 50 ft City Streets, Expressway ramps*	 Expressway Mainline†
Autos	58.8	64.3
Medium Trucks (2 axle, 6 tire)	73.9	75.7
Heavy Trucks (3 or more axles)	83.2	81.6

*"West Side Highway Project, Final Environmental Impact Statement," FHWA-NY-EIS-74-03-F.

†"FHWA Highway Traffic Noise Prediction Model," FHWA-RD-77-108.

Noise Source	Emission Level*, dBA at 50 ft.
Commuter Rail Locomotives (F40PH)	Moving = 90.8; Idle = 88
Green Line	†

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*See "Ellis Neighborhood Acoustic Scale Model Study," BBN Report 3925.

†A different computation was used; see Green Line Computations below.

Speeds (S)

Noise Source	Speed (mph)
City streets and Expressway ramps	25
Expressway mainline	35
Rail line	25
Rail yard	10
Green Line	--*

*See Green Line Computations.

Volumes (V)

Auto, medium truck, and heavy truck volumes (ADWT's) were taken from BRA-supplied maps. Green Line and commuter rail volumes were provided by MBTA. The following tables summarize the relevant assumptions.

	Percent (%) of Total Daily Volume During:		
Noise Source	Day	Night	Year(s)
City streets	80	20	All
Expressway mainline and ramps	75	25	All
Commuter rail	76	24	1980
	88	12	1987 and 200
Green Line	83	17	All

	Percent (%) of Each Vehicle Type	
Noise Source	City streets	Expressway ramps and mainline
Autos	94.9	89.4
Medium trucks	4.3	5.7
Heavy trucks	0.8	4.9

Green Line Computations

The method for computing Green Line noise was derived from "Noise Impact Inventory of Elevated Structures in U.S. Urban Rail Rapid Transit Systems."* The method of that report uses the equation

$$L_{dn} = \text{SENEL} + 10 \log (n_{day}+n_{night}) - 49.4 \text{ dB} \quad ,$$

where n_{day} is the number of cars that pass by during the daytime; n_{night} is the number of cars that pass by during the nighttime; and SENEL is the single event noise exposure level, which equals 83 dBA at 50 ft. For alternative 1A (refurbished baseline case), a 3-dB reduction in noise levels was assumed, consistent with a preliminary draft of the MBTA's Green Line Alternative EIS.

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*U.S. Department of Transportation Report No. UMTA-MA-06-DO99-80-5 (September 1980).

TABLE II-2. RESULTS OF NOISE LEVEL COMPUTATIONS

Location*/	Noise Source	Day-Night Sound Level, dB L_{dn} by Alternative									
		No-Build			Preferred				Reduced Scale		
						2000 Green Ln. Alt.			2000 Green Ln. Alt.		
		1980	1987	2000	1987	1A	3	5C	1A	3	5C
1	Roads	72	72	73	73	68	68	68	72	72	72
	Rail	79	77	77	77	62	62	62	62	62	62
	Green Ln.	50	50	50	50	—†	—	—	47	50	50
	Total	80	78	78	78	69	69	69	72	72	72
2	Roads	—	—	—	—	72	72	72	72	72	72
	Rail	—	—	—	—	64	64	64	64	64	64
	Total	—	—	—	—	73	73	73	73	73	73
3	Roads	—	—	—	—	74	74	74	—	—	—
	Green Ln.	—	—	—	—	53	56	58	—	—	—
	Total	—	—	—	—	74	74	74	—	—	—
4	Roads	71	71	71	72	72	72	72	72	72	72
	Green Ln.	63	63	63	63	60	63	57	60	63	57
	Total	72	72	72	73	72	73	72	72	73	72
5	Roads	73	73	74	73	74	74	74	74	74	74
6	Roads	—	—	—	—	79	79	79	79	79	79
	Green Ln.	—	—	—	—	—	52	—	—	52	—
	Total	—	—	—	—	79	79	79	79	79	79
7	Roads	—	—	—	—	82	82	82	82	82	82
	Green Ln.	—	—	—	—	—	55	—	—	55	—
	Total	—	—	—	—	82	82	82	82	82	82
8	Roads	—	—	—	73	74	74	74	74	74	74
	Green Ln.	—	—	—	59	56	68	—	56	68	—
	Total	—	—	—	73	74	75	74	74	75	74

*For location see Fig. II-1.

†"—" (dash) means that either the source contributes no significant noise in that alternative/year, or that the noise-sensitive location does not exist for that alternative/year.

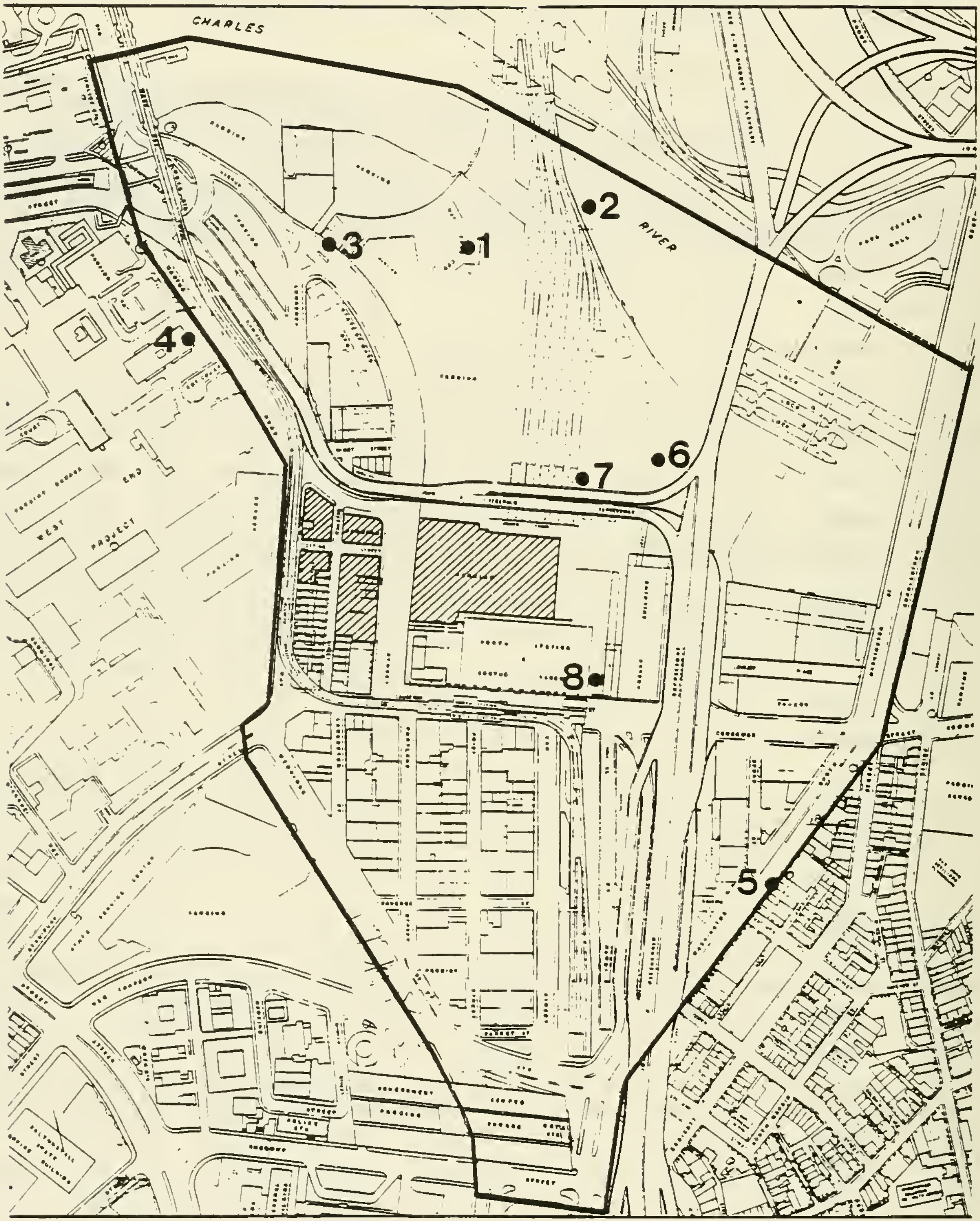


FIG. II-I. NOISE SENSITIVE LOCATIONS FOR WHICH EXISTING AND FUTURE DAY-NIGHT SOUND LEVELS WERE COMPUTED.

APPENDIX G-2

NOISE IMPACT ANALYSIS METHODOLOGY

(North Station Green Line Alternatives Analysis)

Noise generated by transit passbys on elevated lines has been measured recently and reported by Towers, 1980, including the Green Line segment from North Station to Science Park Station. This report served as the source of noise exposure data for each passby. From this, the Day-Night level, L_{dn}, was computed using train schedule projections to the year 2000 provided by Cambridge Systematics as part of the present project studies.

Each passby generates a noise exposure called SENEL: the Single Event Noise Exposure Level, defined as the sound level, in dBA, of a signal with duration of one second that contains the same acoustic energy as the time-integral sound level of a single train or transit car passby. The SENEL is equivalent to the area under the time history curve of noise level associated with a single passby. In practice, it is measured or approximated in several ways. The level can be traced on a chart recorder and the area measured, or SENEL can be approximated for a straight section of rail with a constant speed train from:

$$\text{SENEL} \qquad L_{max} + 10 \log T_5$$

where:

L_{max} = the maximum peak noise at closest passing, and
T_5 = the time interval, in seconds, between points on the curve where the sound level is 5 dBA below L_{max}.

From the Towers study, values for SENEL were obtained and corrected to noise events for single-car passbys, since Green Line transit passbys are a daily mixture of one- and two-car PCC trains.

The average SENEL values are for a mixed fleet of the older (and louder) PCC cars and the damped LRV cars. For the purposes of this study, a worst case projection was used, and it was assumed that the mix of cars continued to be the same as during Towers' study. Actual noise levels will decrease because of noise abatement projects currently planned or underway by the MBTA, including retrofitting PCC cars with quieter wheels, and the use of wayside noise barriers on new lines to reduce the potential for noise impacts on the wayside community.

From the data in Appendix F of Towers, 1980, the SENEL for a single-car passby was obtained as a function of distance of the receptor from the nearest Green Line track, d, in feet.

$$\text{SENEL} = 100.2 - 10\log(d,\text{ft})$$

To obtain a figure for the total day, this energy level would be multiplied by the number of cars scheduled during the day and multiplied by the number of nighttime cars, with a 10 dBA penalty added for the latter. Since 10 dB is equivalent to a factor of ten, the equation would be written:

$$\text{Day-night energy} = 10^{(L_{dn}/10)} =$$

$$10^{(SENEL/10)} \times (N_d + 10N_N)/86400$$

where:

N_d = the car scheduled between 7:00 a.m. and 10:00 p.m., and
N_n = the number of cars scheduled between 10:00 p.m. and 7:00 a.m.
86400 = seconds in 24 hours

In logarithmic form:

$$L_{dn} = SENEL + 10\log (N_d + 10N_n) - 49.4$$

To complete the model, the value for the SENEL as a function of distance is substituted:

$$L_{dn} = 100.2 - 10\log(d,ft) + 10\log(N_d + 10N_n) - 49.4$$

$$= 50.8 - 10\log(d,ft) + 10\log(N_d + 10N_n)$$

For scheduling purposes, existing and future approximate car schedules are provided in Table A4.1.

Table A4.1

SCHEDULE PROJECTIONS FOR GREEN LINE CARS

Year	Day (7:00 a.m. to 10:00 p.m.)	Night (10:00 p.m. to 7:00 a.m.)	Level Increase
Present	505	101	0
1985	535	110	+0.3 dB
2000	565	119	+0.6 dB

As indicated in the right column, these changes make very small additions to the L_{dn} values, totaling only 0.6 dB by the year 2000.

The receptors were chosen for the evaluation of the long term noise impact. Existing L_{dn} values for the first seven receptors were obtained from modeling reported by BBN for the Boston Redevelopment Authority Interim Environmental Impact Report for commuter rail line noise and for traffic noise levels from the Central Artery and approach ramps. Additional Receptors 8, 9, and 10 were chosen as being the closest residences to the existing elevated structure not adequately represented by the original BRA seven receptors. Traffic noise levels projected by the BRA to the year 2000 were found to closely approximate the following empirical formula, where (d) is the distance, in feet, from the closest lane of the Central Artery or ramp.

L_{dn} (traffic) = 98.3 - 10log(d,ft)

This model was modified slightly, by subtracting 3dB for ramp noise involving one-way traffic only, but it gives good agreement with the levels reported in the BRA study for Receptors 1 to 7. It was therefore used to approximate the noise levels for Receptors 8 through 10.

Sound levels in dB cannot simply be added to obtain a total level, since they are logarithmic, and addition would actually imply a multiplication of power levels. Each dB level must be converted into its power equivalent, these are then added, then the result is converted back into dB. For example,

60 dB becomes $10^{(60/10)} = 10^6 = 1{,}000{,}000$, and
70 dB becomes $10^{(70/10)} = 10^7 = 10{,}000{,}000$

Adding together: $1{,}000{,}000 + 10{,}000{,}000 = 11{,}000{,}000$

Converting back to dB: $11{,}000{,}000 = 10^{7.04}$ or 70.4 dB

Using this procedure, L_{dn} values for vehicular noise, commuter rail noise, and transit noise were added for each receptor. For the purpose of illustrating the minor effect of the transit noise on the total L_{dn}, the results were tabulated preserving fractional values; this does not imply that projections of values of less than one dB have such exact physical accuracy.

Source: Jason M. Cortell Associates, Appendix 3 of U. S. Department of Transportation, Urban Mass Transportation Administration, Draft Environmental Impact Statement - Boston Green Line at North Station: Alternative Improvements (Preliminary Draft), July, 1981.

Appendix H SERVICE (ACCESS) ROAD FEASIBILITY STUDY

BOSTON REDEVELOPMENT AUTHORITY

NORTH STATION PROJECT

SERVICE (ACCESS) ROAD FEASIBILITY STUDY

GENERAL

The Service (Access) Road as proposed by the BRA connects Nashua Street with Accolon Way and Beverly Street. The road will be primarily used to service the future Parking Garage structure and the future Arena basement parking garage and will allow direct access to the Expressway Ramps on Causeway Street opposite Beverly Street.

Presently the Service Road is intended to be a two way, forty-six foot (12'-11'-11'-12' lanes) wide street. It will be constructed beneath the future proposed Parking Garage and Arena structures and has been studied relative to being below the future MBTA extended tracks or platform area and will run parallel and adjacent to the John E. Fitzgerald Expressway Ramps.

Presently, the Service Road is planned to be constructed as a part of the proposed Arena. The new MBTA Green Line is also intended to be housed within the Arena complex relocated to above the Service Road.

Horizontal Control Points

In order to maximize the proposed Parking Garage and Arena's usable space, the roadway should be located as close to the Expressway Ramps as possible.

Of major consideration is the proximity of the existing Expressway Ramp column pile foundations. However with an extensive, sheeting/bracing/tie-back system the Roadway/Arena can be placed close to the ramp foundation pile caps but not closer than the battered concrete piles will permit.

Horizontal sight distance for oncoming traffic will also impact both the Arena parking garage entrance (also the Nashua Street Parking Garage) and the Service Road as it divides and weaves through the Expressway columns at Beverly Street.

The Service Road/Accolon Way/Beverly Street layout must accommodate the movement of service trucks for both the Arena and 150 Causeway Street (Annalex Building). This is farther complicated as the study points out by the inability of connecting the Service Road to Accolon Way because of grade problems under some Service Road schemes.

Vertical Control Points

The Service Road vertical control points are; to be at grade at Nashua Street, a major intersection which includes the intended entrance/exit area for the proposed Parking Garage and to avoid the excessive relocation of utilities including the BWSC Concrete Overflow Conduit; to be at grade at the Accolon Way/Beverly Street area at the opposite end in order to allow for the movement of future Arena service vehicles into Accolon Way and parking garage patrons to access the expressway ramps opposite Beverly Street; and vehicle vertical clearance restrictions in the area of the MBTA tracks which would be extended over the Service Road or in lieu of this a pedestrian walkway at the elevation of an intended platform servicing the RR cars also extending over the Service Road.

Also, the future Pedestrian Concourse must be capable of passing over the Service Road and still have adequate clearance to go under the Expressway Ramp Structure. Sufficient clearance must also exist to clear the MBTA Green Line supporting structure immediately above the Service Road.

Again, a vertical consideration is the proximity of the Expressway Ramp pile foundation system. The closest alignment would be that which would not interfere with the ramp foundation's battered piles.

Another factor which is dependent on the elevation of the Service Road is the future Pedestrian Concourse as it passes over the Service Road and under the Expressway Ramp structure members to connect with future northerly development.

STUDY CRITERIA

Vertical Clearances

Used -

Minimum - 10'-6"	Accommodates:	Passenger Cars	4'-10" to 5'-4"
		Large Vans	6'-7"
		Campers	9'-1" and up.
		Motorhomes	8'-8"
		Delivery Vans	7'-0"
Maximum - 14'-6"	Accommodates:	All of the above	
		Semi-Trailer Trucks	13'-6"

Massachusetts D.P.W. - Min. 14'-6" "Bridge Clearances - Local Road Under" (For all Vehicles)

Callahan & Sumner Tunnels - Signed 12'-6"

A.S.S.H.O. - Min. 14' or at least 1' greater than legal height load.
- Depressed facility restricted to passenger vehicles:
14' Desirable
12'-6" Min.

An absolute minimum vertical clearance of 10'-6" restricted to passenger vehicles was chosen keeping in mind the severe constraints of the design and the possibility of acceptance. In any case, the actual vertical clearance will require approval from the State D.P.W.

It is recognized that a minimum 12'-6" vertical clearance may be imposed by the State. Therefore the feasibility of the Service Road at 12'-6" can be attained through interpolation of the data generated at the 10'-6" and 14'-6" clearances.

Grades

Used -

Maximum - 12%

Massachusetts D.P.W. - Maximum 6% with steeper grades allowed on downgrades.

A.S.S.H.O. - 12% for Hilly Arterial Streets @ 30 MPH.

The most constrained Alternative studied (MBTA Tracks extended and 14'-6" clearances) requires 12% grades to meet all control points.

Design Speed

Used -

Minimum - 20 MPH

Again, the most constrained Alternative could only support a design speed of 20 MPH because of the minimum stopping sight distance or headlight sight distance of 125' associated with this speed through the vertical curve system. A design speed of less than 20 MPH was not considered applicable to the character of the Service Road and therefore was not studied.

Where possible sight distances were increased as large as possible and in turn would allow greater design speeds.

Tunnel Roadway Section

A tunnel roadway section of four, 12'-11'-11'-12' lanes, 2 in each direction with a 1'-6" offset from the curb to wall on the northerly or expressway ramp side and a minimum 3' safety walk on the southerly side was used to maximize the usable Arena basement space. This tunnel section is shown as a direct extension of the lane arrangement of the typical roadway section to keep widths to a minimum even though it is desirable to have a tunnel section 2' wider than the approaching roadway. This 2' width increase could be accomplished, if warranted, without any significant effects.

Total bottom slab thickness was assumed at 3' with a 1' crushed stone mud mat with 2' thick walls. This configuration would assist in offsetting the hydrostatic uplift forces on the tunnel section because of the relatively high water table (approximately Elevation 8 in December 1981/January 1982).

For Alternative II, MBTA Tracks Extended, a 4'. deep beam roof system with an 8" slab was assumed to support the extended RR tracks above.

For Alternative III, MBTA Tracks Not Extended/MBTA Platform Extended, a 30" deep concrete plank section was assumed to support the pedestrian walkway above leading to the train platform.

For the Pedestrian Concourse over the Service Road an 18" deep concrete plank system was used.

ALTERNATIVES

The Service Road was studied using three alternatives:

I. No Build

II. MBTA Tracks Extended.

  A. All vehicles allowed.
  B. Passenger vehicles only.

III. MBTA Tracks Not Extended; RR Platform Extended.

  A. All vehicles allowed.
  B. Passenger vehicles.

I. No Build

PM peak hour traffic volumes for the year 2000 Preferred Program, as development by the BRA and adjusted by CEM for elimination of Service Road, were used. An assumption was that the elevated MBTA structure will be eliminated allowing full 35' roadways on Lomasney Way and Causeway Street and Lomasney Way at Causeway Street has a four lane approach with two left turn lanes.

The Critical Movement Analysis (Planning) from Transportation Research Circular #212 was used to determine levels of service for surrounding signalized intersections. The results are as follows:

	LEVELS OF SERVICE	
INTERSECTION	WITH ACCESS RD.	NO ACCESS RD
1. Lomasney Way at Martha Road & Service Rd.	B*	D*
2. Lomasney Way at Causeway St., Merrimac St. & Staniford St.	D*	F*
3. Causeway St. at Beverly St. & Expressway Ramps	C	C

* Analyzed assuming no pedestrian actuation.

The decrease in Levels of Service at the Intersection 1 & 2 area are a result of traffic traveling between the Parking Garage and Intersection 1 using Causeway Street and Lomasney Way instead of the Service (Access) Road.

For supportive data see attached Critical Movement Analysis sheets.

II. MBTA Tracks Extended

(See Plan/Profile Sheet No. 1 of 2)

IIA. All Vehicles Allowed

As previously discussed, with the railroad tracks extended the supporting roof system of the Service Road at the track locations would be in the order of 4' deep with an 8" slab.

Using a vertical clearance height of 14'-6" at the extremities of the commuter station tracks to allow all vehicles sets the vertical control for this Alternative. The minimum, steepest grade which will accommodate these controls is 12% with a maximum design speed of 20 MPH.

In order to attain the minimum 125' Headlight or Stopping Sight Distance for 20 MPH the entire length of the depressed section from Nashua Street to Accolon Way/Beverly Street is comprised of vertical curves precluding desirable tangent lengths for intersection approaches and between vertical curves.

Because of the steep grades the roadway is driven down to a depth below the grade of approximately 23' or Elevation -6.0, well below the water table, Elevation 8.

Access to Accolon Way from the Service Road would not be possible because Accolon Way falls within the 12% incline of the Service Road. Concurrently Accolon Way would have to have a 12% cross slope at the junction with the Service Road which for a 35' roadway would mean a 4.2' difference in elevation from one gutter to the other. In addition, the Service Road is approximately 10' below grade at this location which would take 100' @ 10% for Accolon to meet grade which is beyond the area designated for Arena Service Docks.

IIB. Passenger Vehicles Only

Again using the previously described roof system for the extended railroad tracks but now using a vertical clearance of 10'-6" which restricts access to passenger vehicles, the minimum, steepest grade now becomes 9% with the design speed still held at 20 MPH.

With the design speed still essentially held at 20 MPH, by maximizing the length of vertical curves, Headlight and Stopping Sight Distances of approximately 155' were achieved again sacrificing any tangent lengths at intersections or between the vertical curves.

This alternative is approximately 18.5' below grade at its lowest point or approximately Elevation -1.2.

Accolon Way again would have poor accessibility from the Service Road being within the Service Roads' 9% incline. This would translate into at 3 foot cross slope differential. Normal roadway cross slopes are in the order of 2-3% with 6% maximums achieved during superelevations (banking). Again, the length required to overcome the Service Road's 8' depth at Accolon would conflict with the intended Arena Service Docks.

III. MBTA Tracks Not Extended/MBTA Platform Extended
(See Plan/Profile Sheet No. 2 of 2)

IIIA. All Vehicles Allowed

This alternative does not extend the commuter rail over the Service Road but uses the loading platform elevation for the commuter trains as the working elevation of an extended pedestrian walkway accessing the platforms to determine the depth of the Service Road. The bottom elevation of the new roof system is controlled by using a height of 4' above the rail as a platform elevation, and a 30" deep support beam.

Using a vertical clearance of 14'-6" below the extremities of the platform to accommodate all vehicles, the minimum, steepest grade is brought down to 7% and the design speed up to 25 MPH.

The Headlight or Stopping Sight Distance approximates 185' by using the entire study area to lengthen the required vertical curves.

A 15' maximum depth below grade or approximately Elevation 2.0 is experienced at the lowest point of this Alternate.

Access to Accolon Way from the Service Road is feasible yet not optimum. The 7% Service Road grade/Accolon cross slope can be traversed and the 6' depth of Service Road overcome prior to the Arena's Service Docks by continuing the 7% grade up Accolon Way with a superelevation (banking) runoff to obviate the extensive cross slope.

IIIB. Passenger Vehicles Only

Utilizing the previously described Pedestrian Platform support system but restricting access to passenger vehicles only through the 10'-6" vertical clearance between the Service Road surface and the bottom of the support beam, grades can be minimized to 4% and the design speed increased to a minimum of 30 MPH.

Considering the 30 MPH design speed as being the maximum warranted for the roadway, Headlight and Stopping Sight Distances are held to a minimum of 230'. Because of this tangent lengths of approximately 75' were able to be incorporated between the various vertical curves.

The roadway is now 10.5' below grade or approximately Elevation 6.5 at the lowest point.

There is no problem in entering Accolon Way from the Service Road. Accolon will have a cross slope of 4% initially and the 4' depth of the Service Road can be made up prior to the Arena Service Docks.

SERVICE ROAD/EXPRESSWAY RAMP FOUNDATIONS

(See Figure 1)

The Expressway ramps are supported by pile foundations. The pile caps are symmetrical about the support columns, ranging in size from 16'x12' to 14'x11', 6' thick with the top being approximately 2-3' below grade. The majority of the concrete piles are battered (1:4) transversely (90°) to the ramps.

Figure 1 shows the relationship between these pile foundations and the future Service Road.

If a normal 1:1 soils prism were used the deepest alternative would cause the roadway to shift some 27' away from the centerline of the columns. Since Arena space is premium this was not considered as a likely location and the relationship was reviewed to establish the roadway as close as possible to the ramps.

In order to keep the northerly Service Road wall as near the Expressway ramps, this wall was assumed to be poured against the sheeting line. Because of the proximity to the ramp foundation this sheeting line will require a tie back system. The critical point for setting the location of the sheeting line was to keep the sheeting tip approximately 4' from the centerline of the battered concrete piles to protect the existing piles. In order to establish this sheeting tip elevation a 3' floor slab with a 1' crushed stone mud mat and a driven tip depth of 2' below the excavation was assumed.

Alternate II - MBTA Tracks Extended with a 14'-6" clearance is the deepest alternative studied with the excavation reaching approximately Elevation - 10.0. With a sheeting tip of -12.0 this causes the roadway northerly wall to be approximately 15' from the centerline of the ramp columns.

Conversely, Alternate III - MBTA Tracks Not Extended/MBTA Platform Extended with a 10'-6" vertical clearance is the shallowest Alternative studied. This can be constructed approximately 12' from the centerline of the ramp columns.

Naturally the other two vertical clearance Alternatives fall in between the 12' and 15' offsets.

Under all the Alternatives the existing MBTA tracks will have to be shortened during construction being in direct conflict with the Service

Road plus the length required to construct the tie back system between ramp bents.

ARENA NORTHERLY WALL FOUNDATION

(See Figure 1)

Alternate II - MBTA Tracks Extended

The new Arena will probably be supported by a column/beam system. With the tracks extended and with no room to install a column between the extended pairs of tracks because of minimum horizontal clearances the new column locations are forced to essentially be in line with the Expressway Ramp bents/foundations.

Assuming the Arena column lines to be coincidental with the northerly wall of the Service Road, the Arena pile caps would have to be offset and the Arena piles significantly coordinated not to interfere with the existing battered ramp piles. This would accent the minimum offset of 15' possibly establishing a greater offset during the Arena design stage.

Alternate III - MBTA Tracks Not Extended/MBTA Platform Extended

Again, the new Arena will probably be supported by a column/beam system on line with the Service Road northerly wall. However with the tracks not being extended the Arena Column locations can be located between the Expressway ramp bents and therefore not be immediately next to the existing ramp pile foundations. This would eliminate the need for offset pile caps and with the existing battered pile between piles being only transverse to the ramps also eliminate direct conflict between proposed and existing piles.

Any foundation system would require the review and approval of the Massachusetts D.P.W. because of the proximity to the Expressway ramps.

SERVICE ROAD/FUTURE PEDESTRIAN CONCOURSE

(See Figure 2 & Plan/Profile of Alternates Sheet 1, 2 of 2)

The future Pedestrian Concourse is intended to run between the GSA Federal Building and Future Parking Garage, and the Future Arena complex connecting the Phase I Area with the future redevelopment north of the Expressway Ramps.

The Pedestrian Concourse alignment is essentially split by Expressway Ramp Column/Bent F13. To the east of this bent a low longitudinal horizontal structural brace exists becoming the vertical control to which the Pedestrian clearances are taken. This bracing system does not exist west of the bent line.

The Concourse vertical control points would be the 1st Floor/Arcade Elevation (19'-8") of the GSA Federal Building, the elevation required to go over the Service Road the with Service Road's various vertical clearance requirements (and under the Relocated Green Line) and be able to go under the exist Expressway Ramp Structure with adequate headroom.

for both extending the existing tracks and relocating the Green Line.

ACCOLON WAY/ARENA SERVICE
(See Figure 3 and 4)

Under Alternate II - MBTA Tracks Extended Accolon Way cannot be accessed from the Service Road due to the Service Road grades and depths. In this Alternate the Service Road retaining walls would be carried through Accolon Way to approximately Station 17+00.

By rearranging curbing the end of Accolon Way can terminate in a turn-around area capable of accommodating WB-50 trucks coming down Accolon Way from Causeway Street. Concurrently an entrance from northbound Beverly Street could be made into the near area of 150 Causeway Street and the Arena area turn-around allowing some circulation. Naturally no access to this area could be made from the eastbound Service Road.

In Alternate III - MBTA Tracks Not Extended/MBTA Platform Extended Accolon Way is connected to the Service Road. Slope cuts are held to a minimum with retaining walls and access to #150 Causeway retained.

Under both alternatives ramp acccess to the 2nd floor of #150 Causeway presently being used by Boston Garden for servicing would not be possible.

ARENA BASEMENT PARKING

Because of the offset arrangement of the MBTA Tracks relative to the foot print of the proposed Arena, the Arena basement parking garage entrance which would be at the bottom of the vertical curve going under the track system will also be offset to the right of center of the Arena.

Assuming that a Arena basement elevation of 10.5 equal to the GSA Federal Building basement is chosen all Alternatives, being lower, would require an up ramp internal to the Arena. The recommended maximum grade in parking garages for any lengths over 65' is 12%. The following table shows the approximate length of ramp required to reach the Arena basement elevation of 10.5.

	Service Road Elevation	Arena Basement Elevation	△	Length @ 12%
Alternate IIA	-6.0	10.5	16.5'	138'
Alternate IIB	-1.2	10.5	11.7'	98'
Alternate IIIA	+2.0	10.5	8.5'	71'
Alternate IIIB	+6.5	10.5	4'	33'

These lengths do not take into account recommended blends of 6% of 12' minimum lengths required to go from 0% to 12%, nor the approach length to the 12% grade (where the ticket booth may be located) nor the turn at the end of the range grade.

Horizontally, another important consideration is the sight distance of a vehicle exiting the parking garage and trying to see on coming Service Road traffic. This would necessitate moving the southerly wall of the Service Road far enough to the south so that the existing vehicle would be entirely behind the curb line and yet see far enough up the eastbound Service Road lanes to accomplish the exit movement safely. This wall set back would be less severe on the easterly side because of the angle of the sight line to the westbound traffic. This criteria would also apply to the future Parking Garage opposite Nashua Street.

UTILITIES

From conversations with various agencies the major utilities requiring prelocation/accommodation would be the Boston Maine Power Conduit Formations running through the current parking at approximately the future Pedestrian Concourse area and servicing both Boston Garden and #150 Causeway Streets and current drainage of the MBTA RR tracks which also are tied into the Expressway Ramp bridge scuppers along with various parking lot catch basin.

A pump station would have to be constructed to drain the Service Road and may also be considered to accommodate the Arena basement.

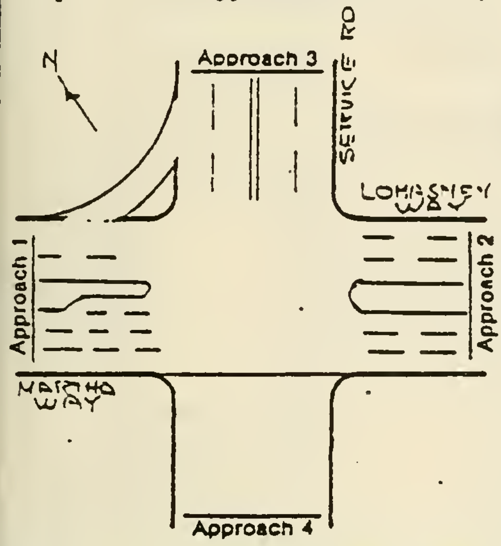
Critical Movement Analysis: PLANNING
Calculation Form 1

ACCESS ROAD

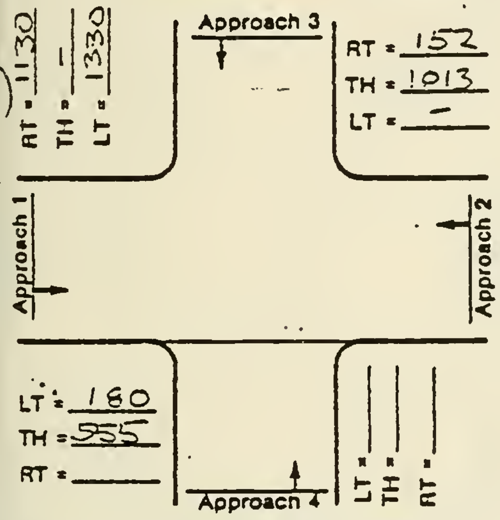
Intersection LOMASNEY WAY MARTHA WAY @ SERVICE RD **Design Hour** 2000 PREFERRED PM PEAK HOUR

Problem Statement FIND LEVEL OF SERVICE

Step 1. Identify Lane Geometry



Step 2. Identify Volumes, in vph



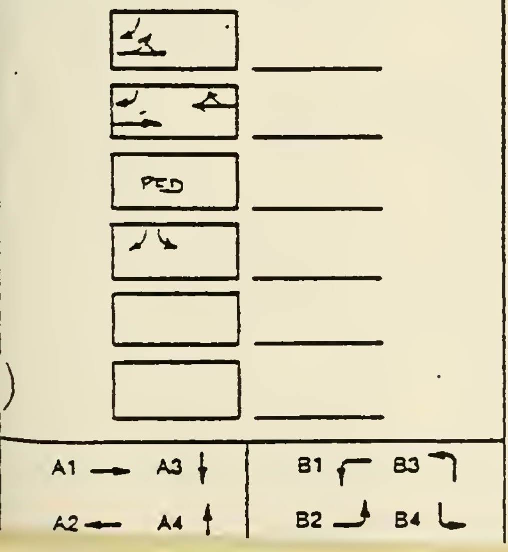
RT = 1130
TH = —
LT = 1330

RT = 152
TH = 1013
LT = —

LT = 180
TH = 555
RT =

LT =
TH =
RT =

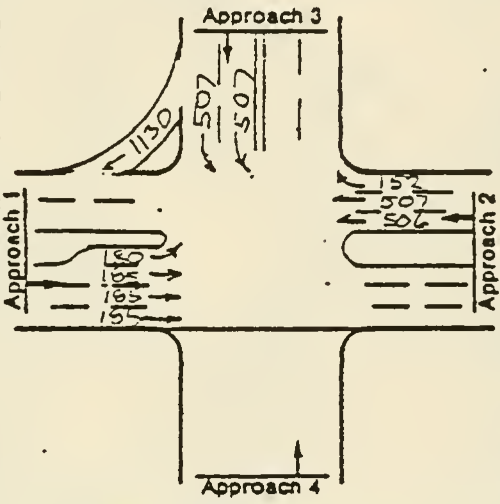
Step 3. Identify Phasing



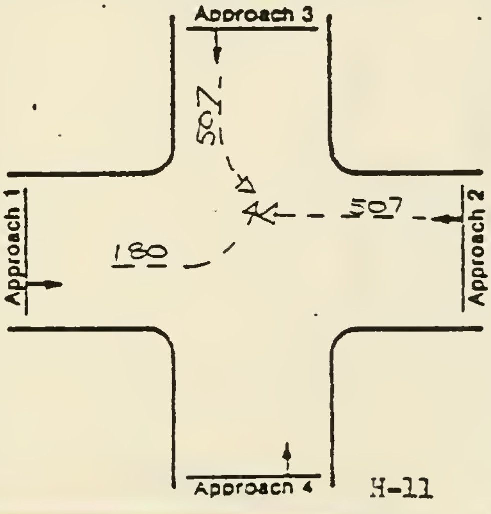
Step 4. Left Turn Check

	Approach 1	Approach 2	Approach 3	Approach 4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + e)				
g. Left turn volume in vph				
h. Is volume > capacity (g > f)?				

Step 5. Assign Lane Volumes, in vph



Step 6a. Critical Volumes, in vph (two phase signal)



Step 6b. Volume Adjustment for Multiphase Signal Overlap

Probable Phase	Possible Critical Volume in vph	Volume Carryover to next phase	Adjusted Critical Volume in vph

3φ

Step 7. Sum of Critical Volumes

180 + 507 + 507 + ______

= 1194 vph

Step 8. Intersection Level of Service

(compare Step 7 with Table 6)

D*

Step 9. Recalculate

Geometric Change ______

Signal Change ______

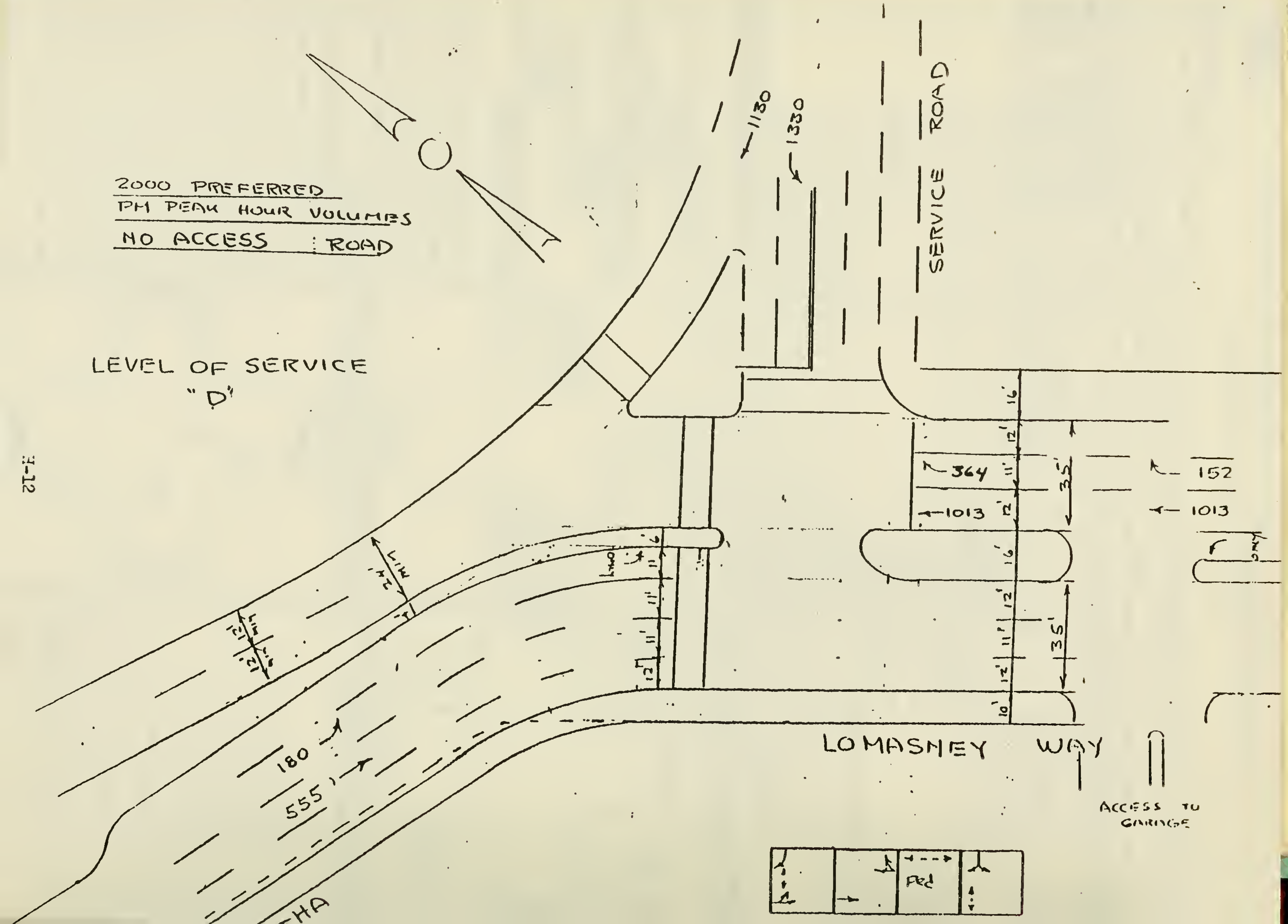
Volume Change ______

Comments

* Assumes ped phase not actuated

2000 PREFERRED
PM PEAK HOUR VOLUMES
NO ACCESS ROAD

LEVEL OF SERVICE
"D"



Critical Movement Analysis: PLANNING
Calculation Form 1

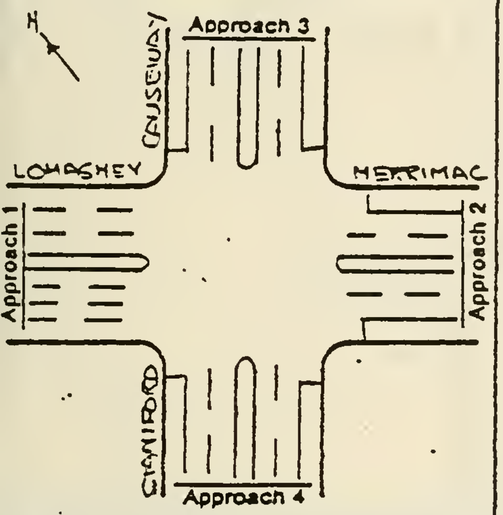
ACCESS ROAD

Intersection LOMASNEY WAY & CAUSEWAY, STANIFORD & MERRIMAC

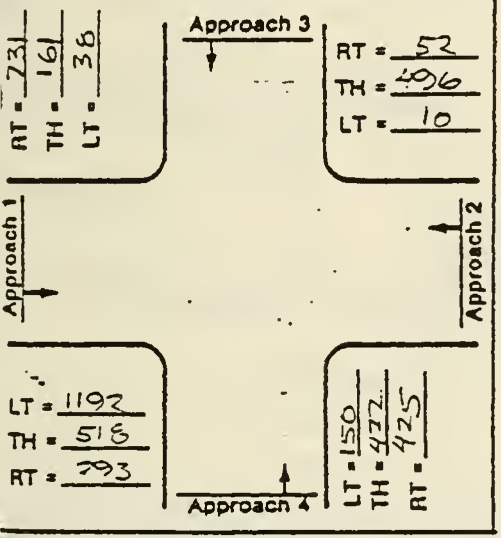
Design Hour 2000 PREFERRED PM PEAK HOUR

Problem Statement FIND LEVEL OF SERVICE

Step 1. Identify Lane Geometry



Step 2. Identify Volumes, in vph



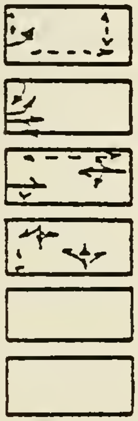
RT = 731
TH = 161
LT = 36

RT = 52
TH = 496
LT = 10

LT = 1193
TH = 518
RT = 793

LT = 150
TH = 477
RT = 425

Step 3. Identify Phasing



ØA

ØA

ØB

ØC

A1 → A3 ↓

A2 ← A4 ↑

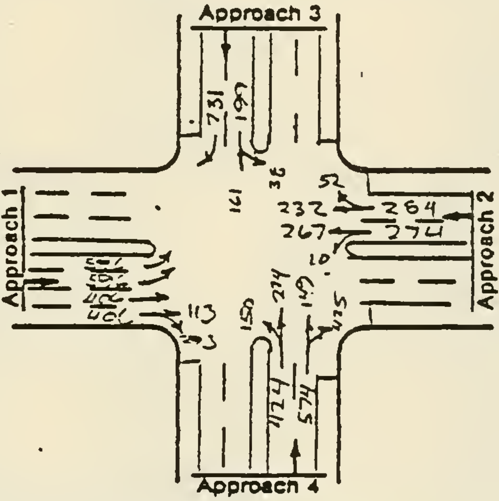
B1 ↱ B3 ↰

B2 ↲ B4 ↳

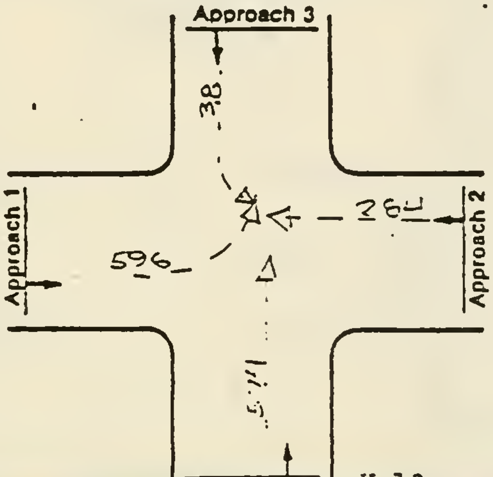
Step 4. Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour		40	40	40
b. Left turn capacity on change interval, in vph		80	80	80
c. G/C Ratio		30	30	30
d. Opposing volume in vph		0	847	526
e. Left turn capacity on green, in vph		360	0	0
f. Left turn capacity in vph (b + e)		440	80	80
g. Left turn volume in vph		10	36	150
h. Is volume > capacity (g > f)?		No	No	Yes

Step 5. Assign Lane Volumes, in vph



Step 6a. Critical Volumes, in vph (two phase signal)



Step 6b. Volume Adjustment for Multiphase Signal Overlap

Probable Phase	Possible Critical Volume in vph	Volume Carryover to next phase	Adjusted Critical Volume in vph
	3 Ø		

Step 7. Sum of Critical Volumes

596 + 264 + 574 + 38 + 100* = 1592 vph

Step 8. Intersection Level of Service

(compare Step 7 with Table 6)

F**

Step 9. Recalculate

Geometric Change

Signal Change

Volume Change

Comments

* Additional 4" all red clearance on two phase.

** Assumes peak phase not actuated

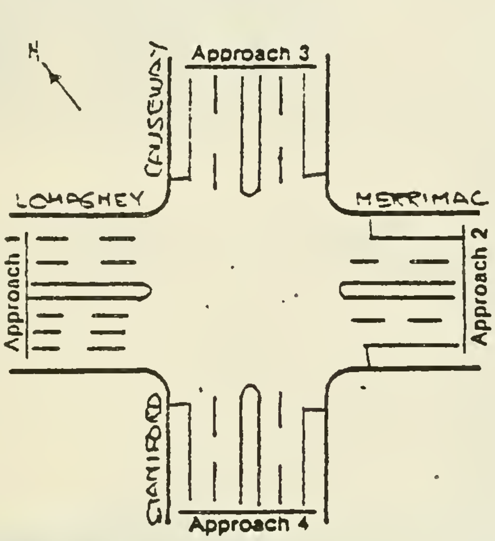
Critical Movement Analysis: PLANNING
Calculation Form 1

ACCES
ROAD

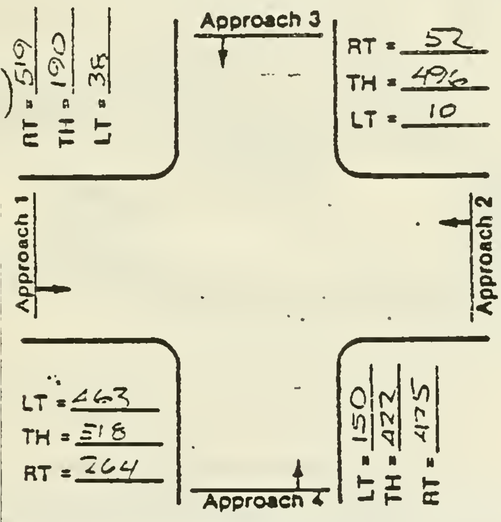
Intersection LOMASNEY WAY @ CAUSEWAY, STANFORD & MERRIMAC Design Hour 2000 PREFER PM PEAK HOU

Problem Statement FIND LEVEL OF SERVICE

Step 1. Identify Lane Geometry



Step 2. Identify Volumes, in vph



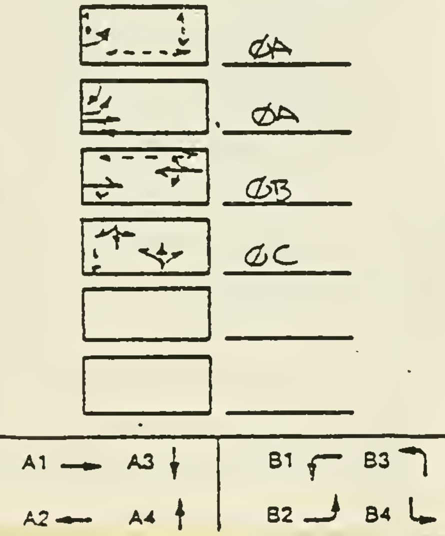
RT = 519
TH = 190
LT = 38

RT = 52
TH = 496
LT = 10

LT = 463
TH = 518
RT = 264

LT = 150
TH = 422
RT = 475

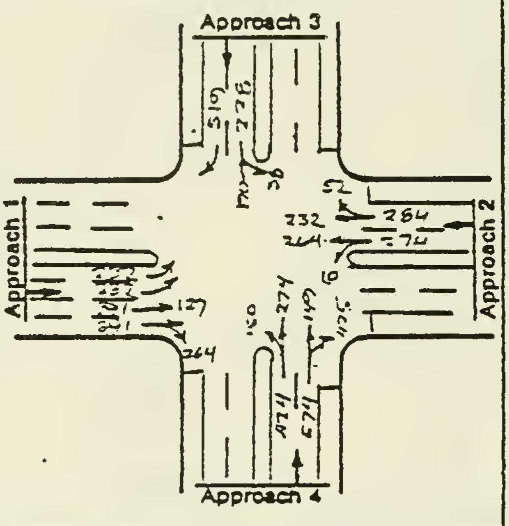
Step 3. Identify Phasing



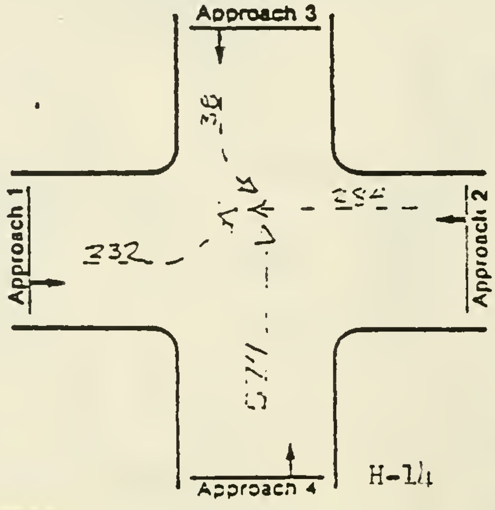
Step 4. Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour		40	40	40
b. Left turn capacity on change interval, in vph		80	80	80
c. G/C Ratio		30	30	30
d. Opposing volume in vph		316	847	449
e. Left turn capacity on green, in vph		42	0	0
f. Left turn capacity in vph (b + e)		122	80	80
g. Left turn volume in vph		10	38	150
h. Is volume > capacity (g > f)?		NO	NO	YES

Step 5. Assign Lane Volumes, in vph



Step 6a. Critical Volumes, in vph (two phase signal)



Step 6b. Volume Adjustment Multiphase Signal Over

Probable Phase	Possible Critical Volume in vph	Volume Carryover to next phase	Adjust Critica Volum in vph

3 Ø

Step 7. Sum of Critical Volu

232 + 284 + 574 + 38

100* = 1228 vph

Step 8. Intersection Level of Service

(compare Step 7 with Table 6)

D**

Step 9. Recalculate

Geometric Change ______

Signal Change ______

Volume Change ______

Comments

* Additional 4" all red clearance on two phas

** Assumes 2nd phase no actuated

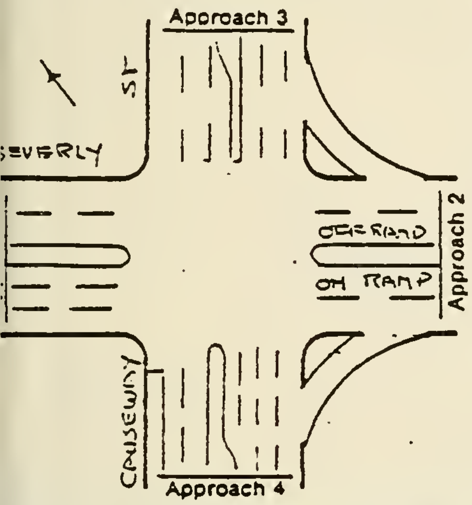
Critical Movement Analysis: PLANNING
Calculation Form 1

NO
ACCESS
ROAD

tersection CAUSEWAY ST @ EXPRESSWAY BEVERLEY Design Hour 2000 PREFERRED PM PEAK HOUR

roblem Statement FIND LEVEL OF SERVICE

tep 1. Identify Lane Geometry



Step 4. Left Turn Check

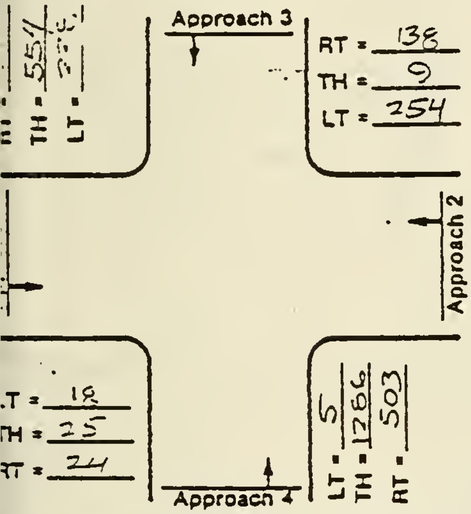
	Approach 1	2	3	4
a. Number of change intervals per hour	40	40	40	40
b. Left turn capacity on change interval, in vph	80	80	80	80
c. G/C Ratio	.30	.30	.30	.30
d. Opposing volume in vph	263	49	1769	782
e. Left turn capacity on green, in vph	97	311	0	0
f. Left turn capacity in vph (b + e)	177	391	80	80
g. Left turn volume in vph	18	254	228	5
h. Is volume > capacity (g > f)?	no	no	yes	no

Step 6b. Volume Adjustment for Multiphase Signal Overlap

Probable Phase	Possible Critical Volume in vph	Volume Carryover to next phase	Adjusted Critical Volume in vph

4Ø

tep 2. Identify Volumes, in vph



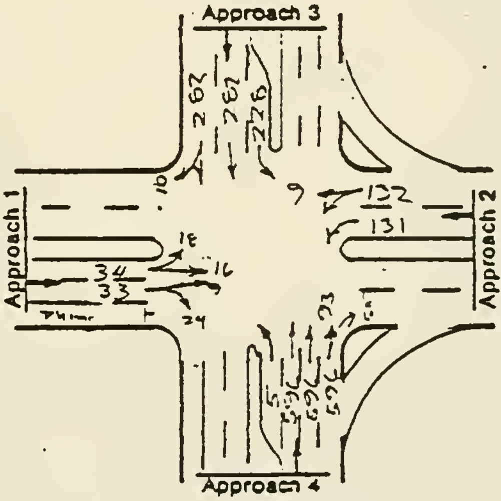
RT =
TH = 551
LT = 228

RT = 138
TH = 9
LT = 254

LT = 18
TH = 25
RT = 24

LT = 5
TH = 1266
RT = 503

Step 5. Assign Lane Volumes, in vph



Step 7. Sum of Critical Volumes

228 + 596 + 33 + 131

= 988 vph

Step 8. Intersection Level of Service

(compare Step 7 with Table 6)

C

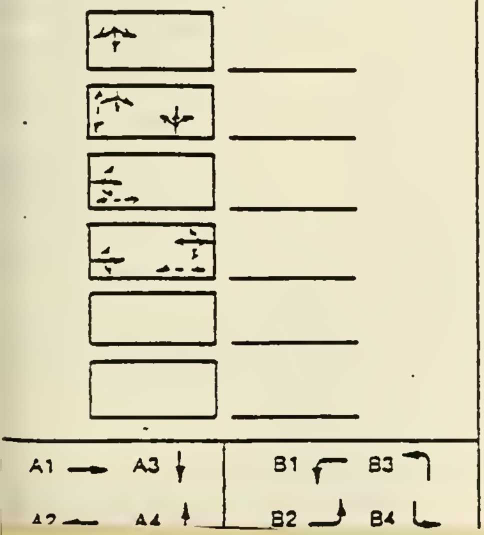
Step 9. Recalculate

Geometric Change ______

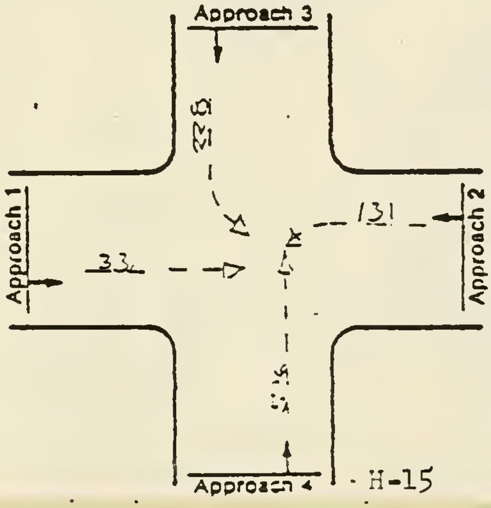
Signal Change ______

Volume Change ______

tep 3. Identify Phasing

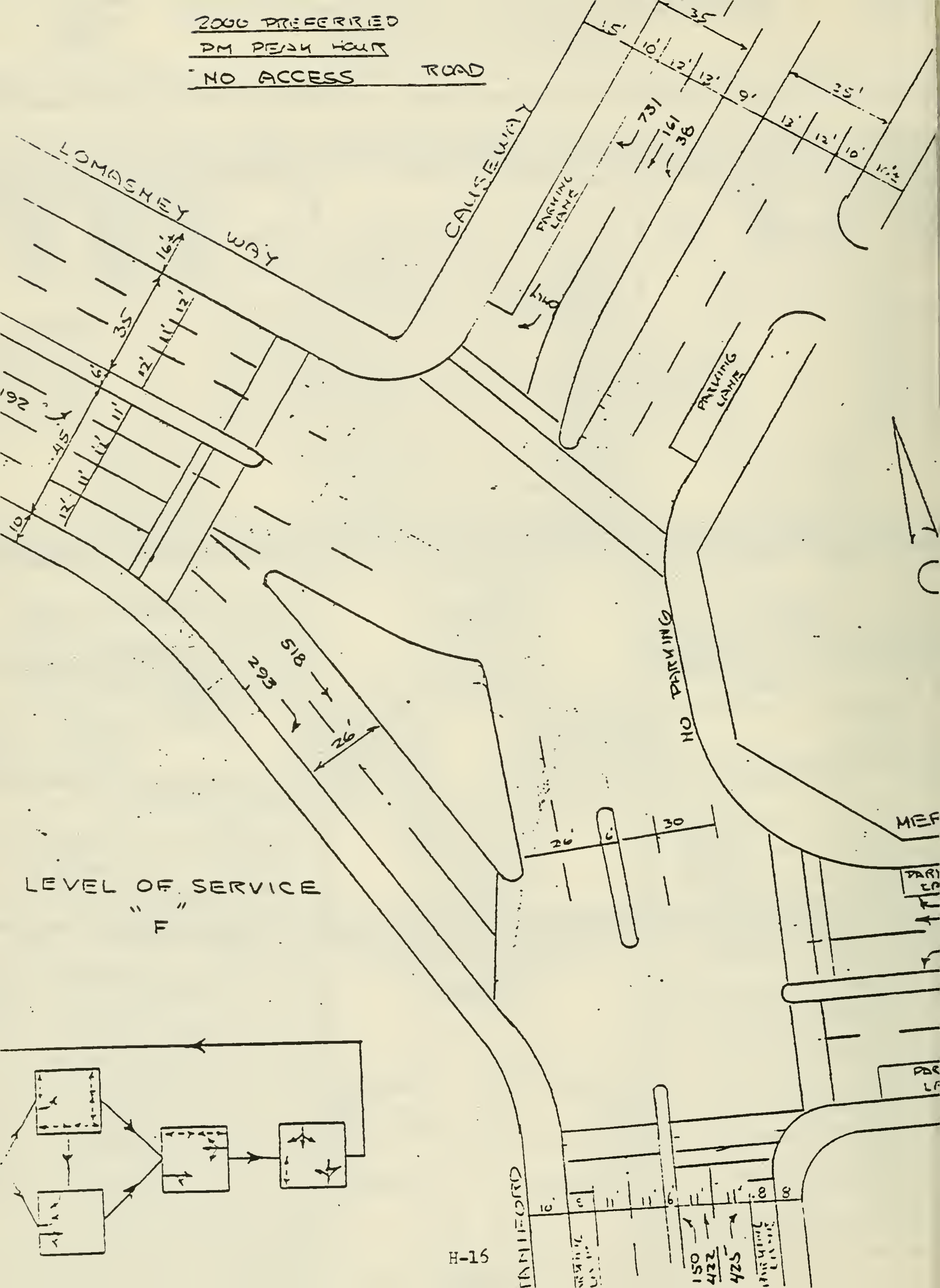


Step 6a. Critical Volumes, in vph (two phase signal)



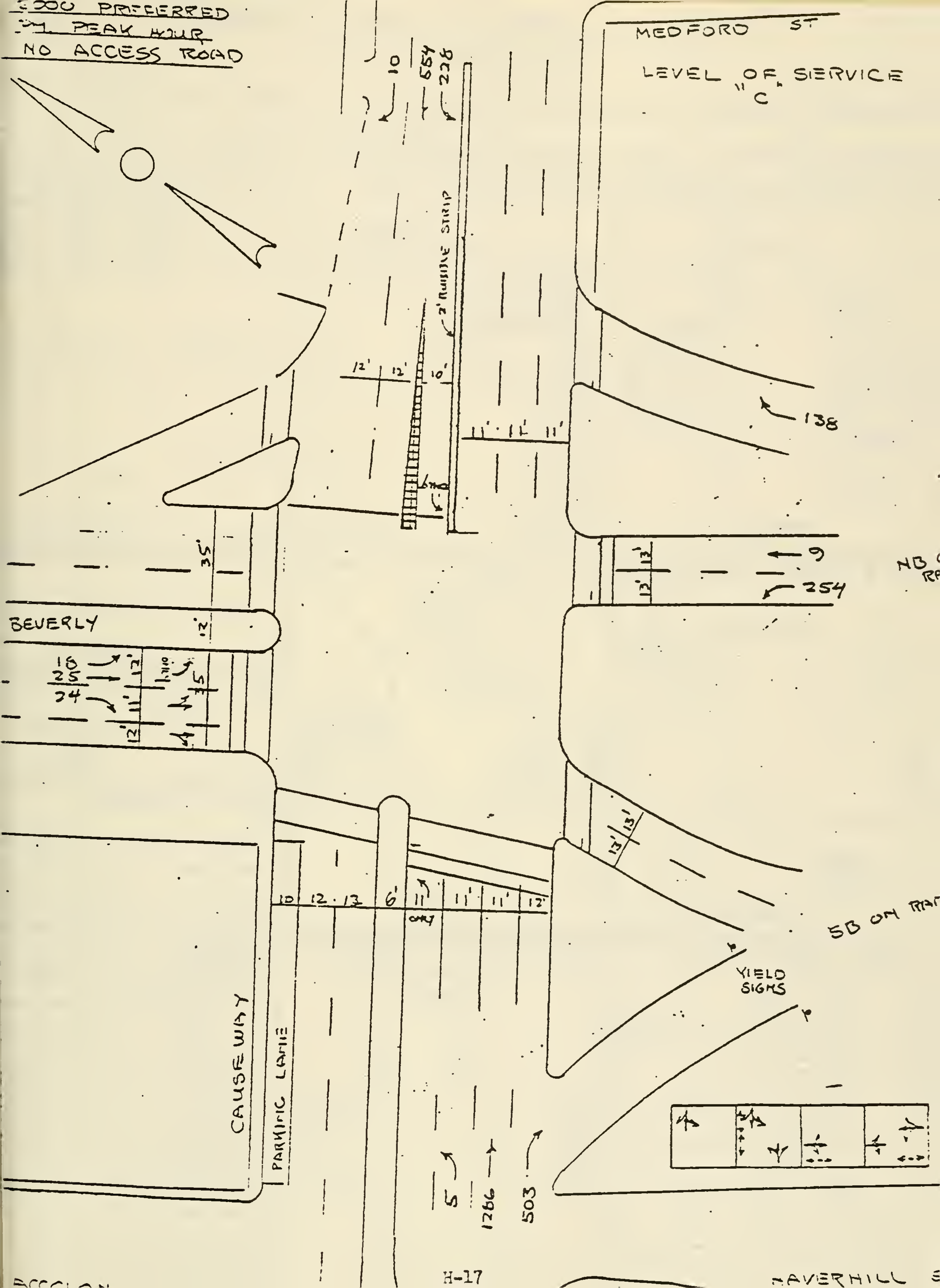
Comments

2000 PREFERRED
PM PEAK HOUR
NO ACCESS ROAD



LEVEL OF SERVICE "F"

000 PREFERRED
PM PEAK HOUR
NO ACCESS ROAD



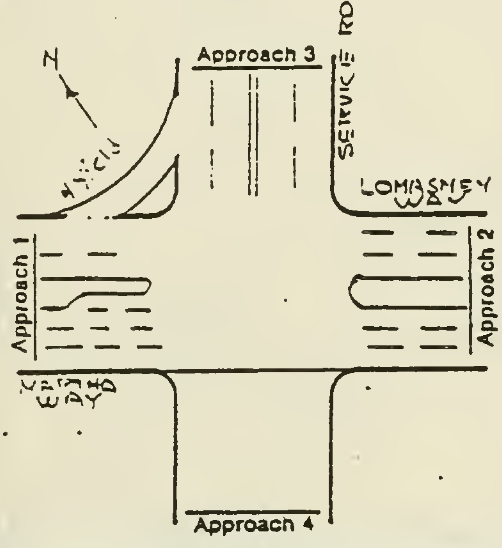
Critical Movement Analysis: PLANNING
Calculation Form 1

ACCESS ROAD

Intersection LOMASNEY WAY MARTHA WAY @ SERVICE RD Design Hour 2000 PRESE PM PEAK HO

Problem Statement FIND LEVEL OF SERVICE

Step 1. Identify Lane Geometry



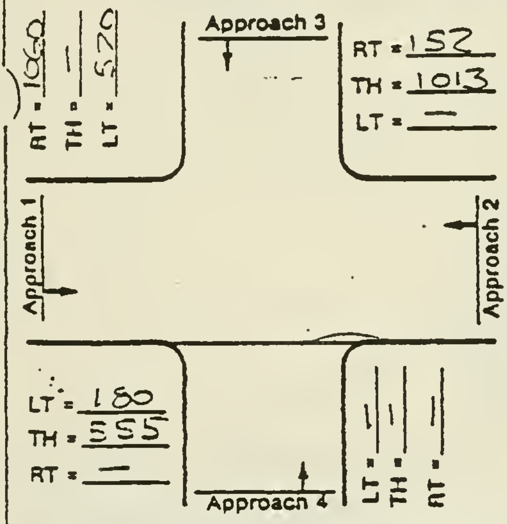
Step 4. Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour				
b. Left turn capacity on change interval, in vph				
c. G/C Ratio				
d. Opposing volume in vph				
e. Left turn capacity on green, in vph				
f. Left turn capacity in vph (b + e)				
g. Left turn volume in vph				
h. Is volume > capacity (g > f)?				

Step 6b. Volume Adjustment Multiphase Signal Ove

Probable Phase	Possible Critical Volume in vph	Volume Carryover to next phase	Adjus Critic Volu in vp
	3 ϕ		

Step 2. Identify Volumes, in vph



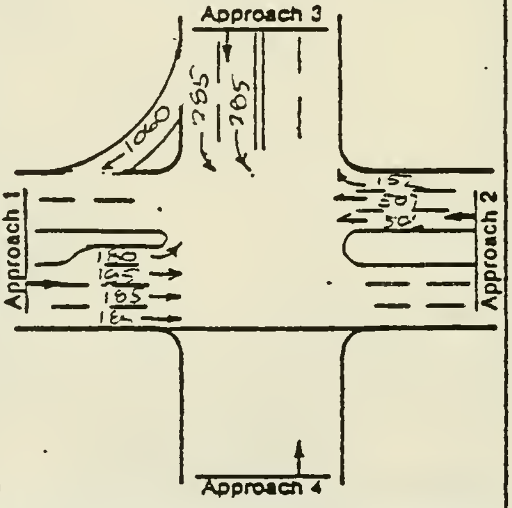
RT = 1060
TH = —
LT = 570

RT = 152
TH = 1013
LT = —

LT = 180
TH = 555
RT = —

LT =
TH =
RT =

Step 5. Assign Lane Volumes, in vph



Step 7. Sum of Critical Volu

180 + 507 + 285 + ____

= 972 vph

Step 8. Intersection Level of Service

(compare Step 7 with Table 6)

B*

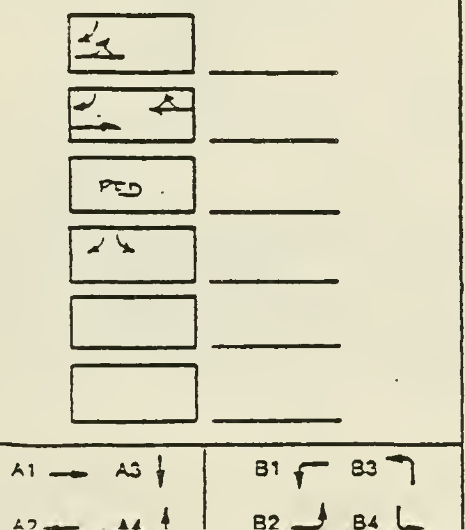
Step 9. Recalculate

Geometric Change ____

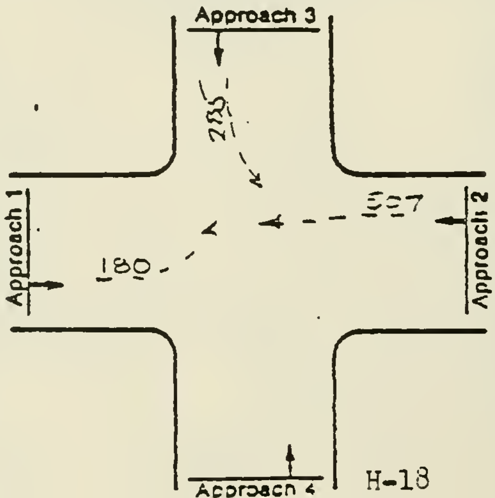
Signal Change ____

Volume Change ____

Step 3. Identify Phasing



Step 6a. Critical Volumes, in vph (two phase signal)

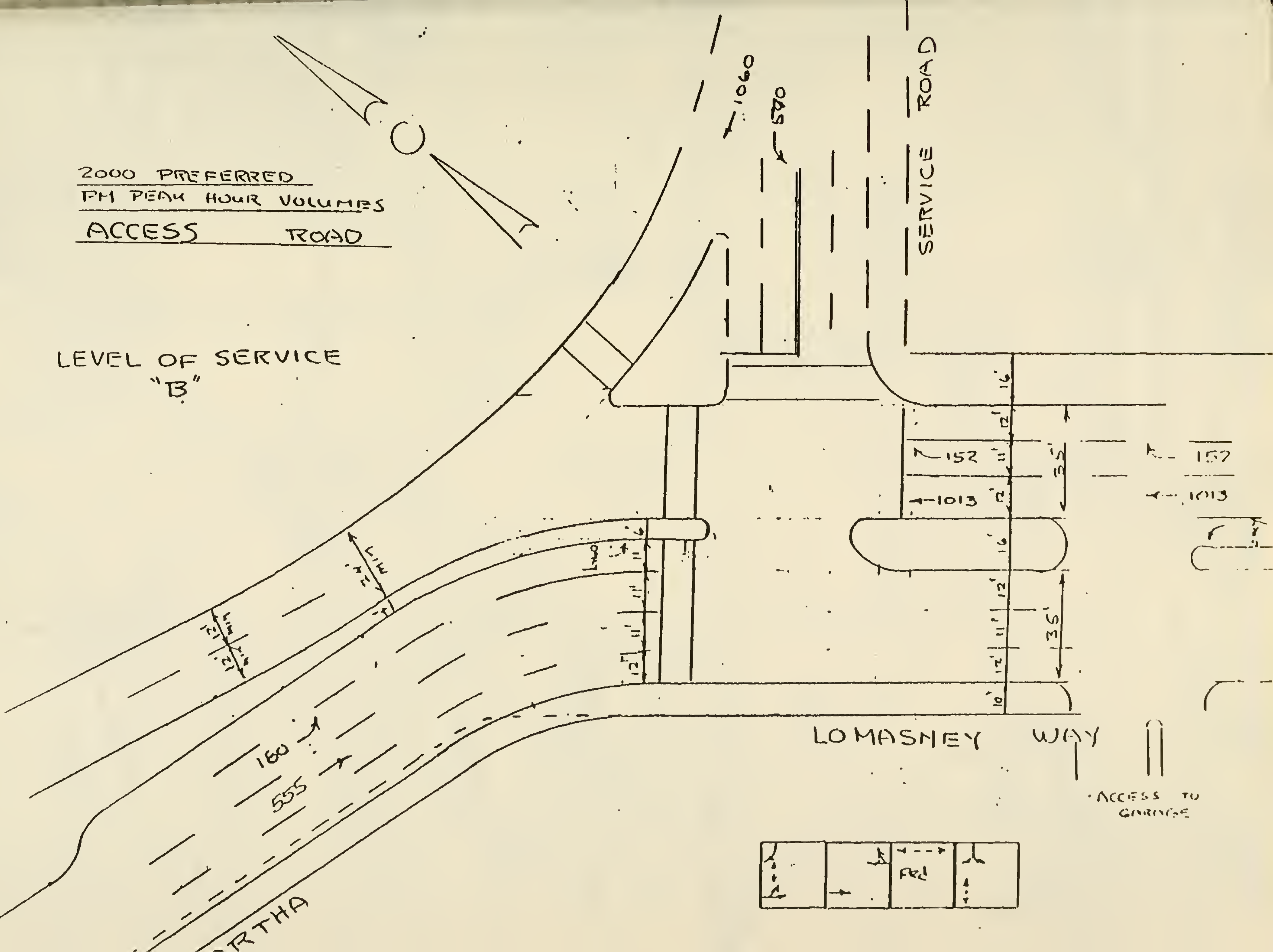


Comments

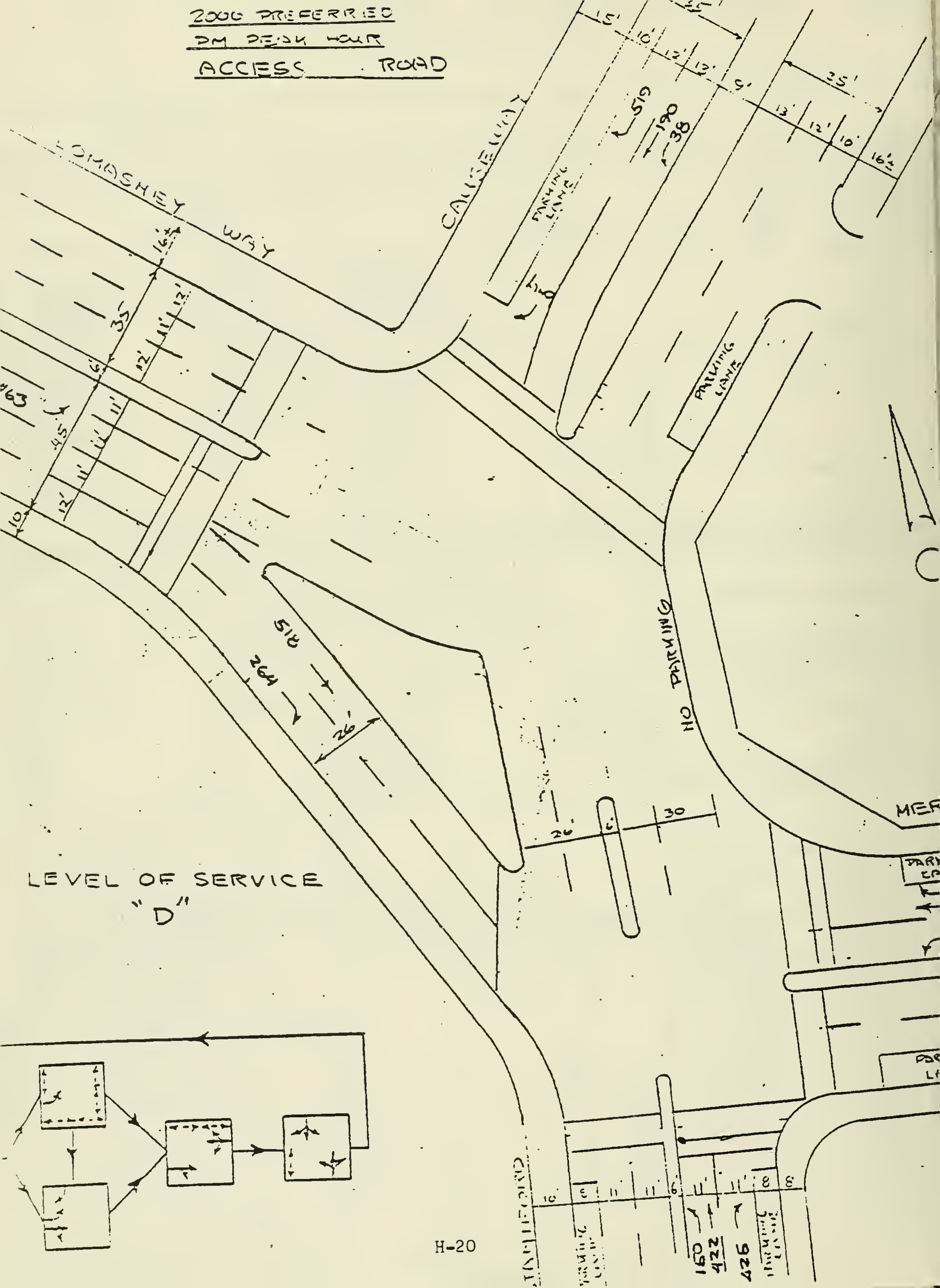
* Assumes Ped phase
actuated

2000 PREFERRED
PM PEAK HOUR VOLUMES
ACCESS ROAD

LEVEL OF SERVICE
"B"



2006 PREFERRED
PM PEAK HOUR
ACCESS ROAD



LEVEL OF SERVICE
"D"

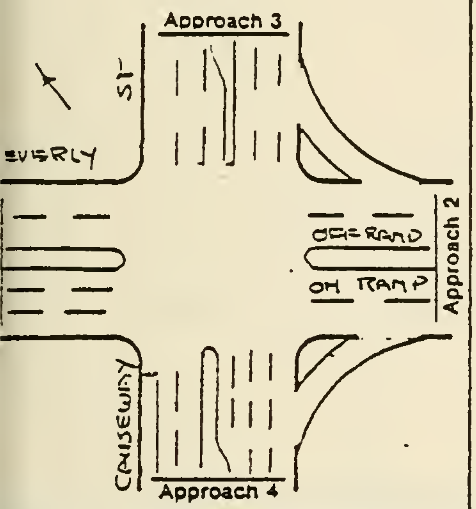
Critical Movement Analysis: PLANNING
Calculation Form 1

ACCESS ROAD

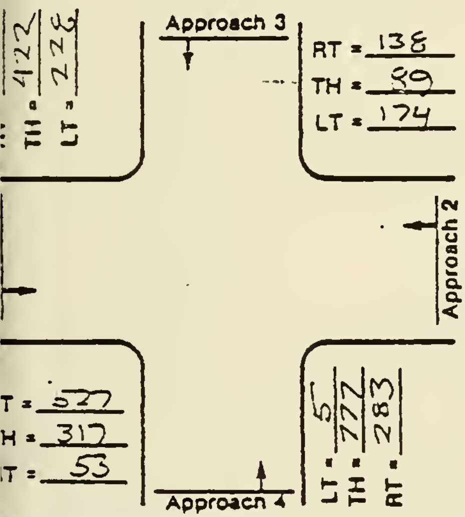
tersection CAUSEWAY ST @ EXPRESSWAY &BEVERLEY Design Hour 2000 PREFERRED PM PEAK HOUR

oblem Statement FIND LEVEL OF SERVICE

tep 1. Identify Lane Geometry



ep 2. Identify Volumes, in vph



tep 3. Identify Phasing

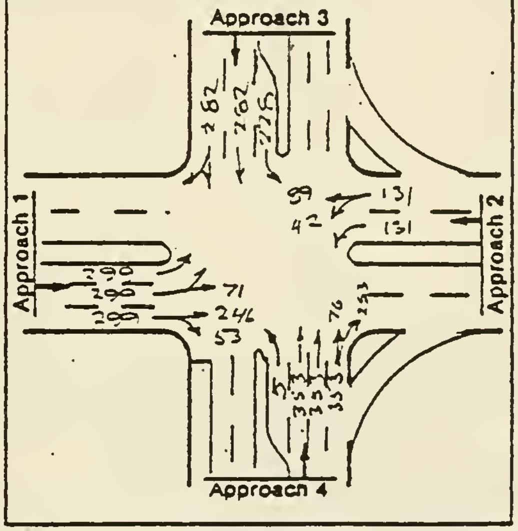
A1 → A3 ↓ B1 ↱ B3 ↴

A2 ← A4 ↑ B2 ⤴ B4 ↳

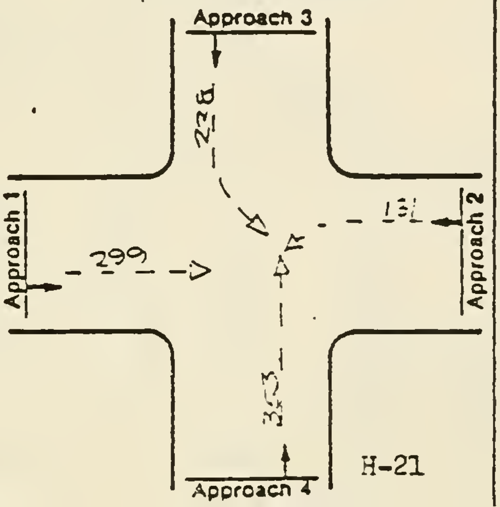
Step 4. Left Turn Check

	Approach 1	2	3	4
a. Number of change intervals per hour	40	40	40	40
b. Left turn capacity on change interval, in vph	80	80	80	80
c. G/C Ratio	.30	.30	.30	.30
d. Opposing volume in vph	263	370	1060	650
e. Left turn capacity on green, in vph	97	0	0	0
f. Left turn capacity in vph (b + e)	177	80	80	80
g. Left turn volume in vph	527	174	228	5
h. Is volume > capacity (g > f)?	yes	yes	yes	no

Step 5. Assign Lane Volumes, in vph



Step 6a. Critical Volumes, in vph (two phase signal)



Step 6b. Volume Adjustment for Multiphase Signal Overlap

Probable Phase	Possible Critical Volume in vph	Volume Carryover to next phase	Adjusted Critical Volume in vph
	40		

Step 7. Sum of Critical Volumes

228 + 353 + 299 + 131

= 1011 vph

Step 8. Intersection Level of Service

(compare Step 7 with Table 6)

C

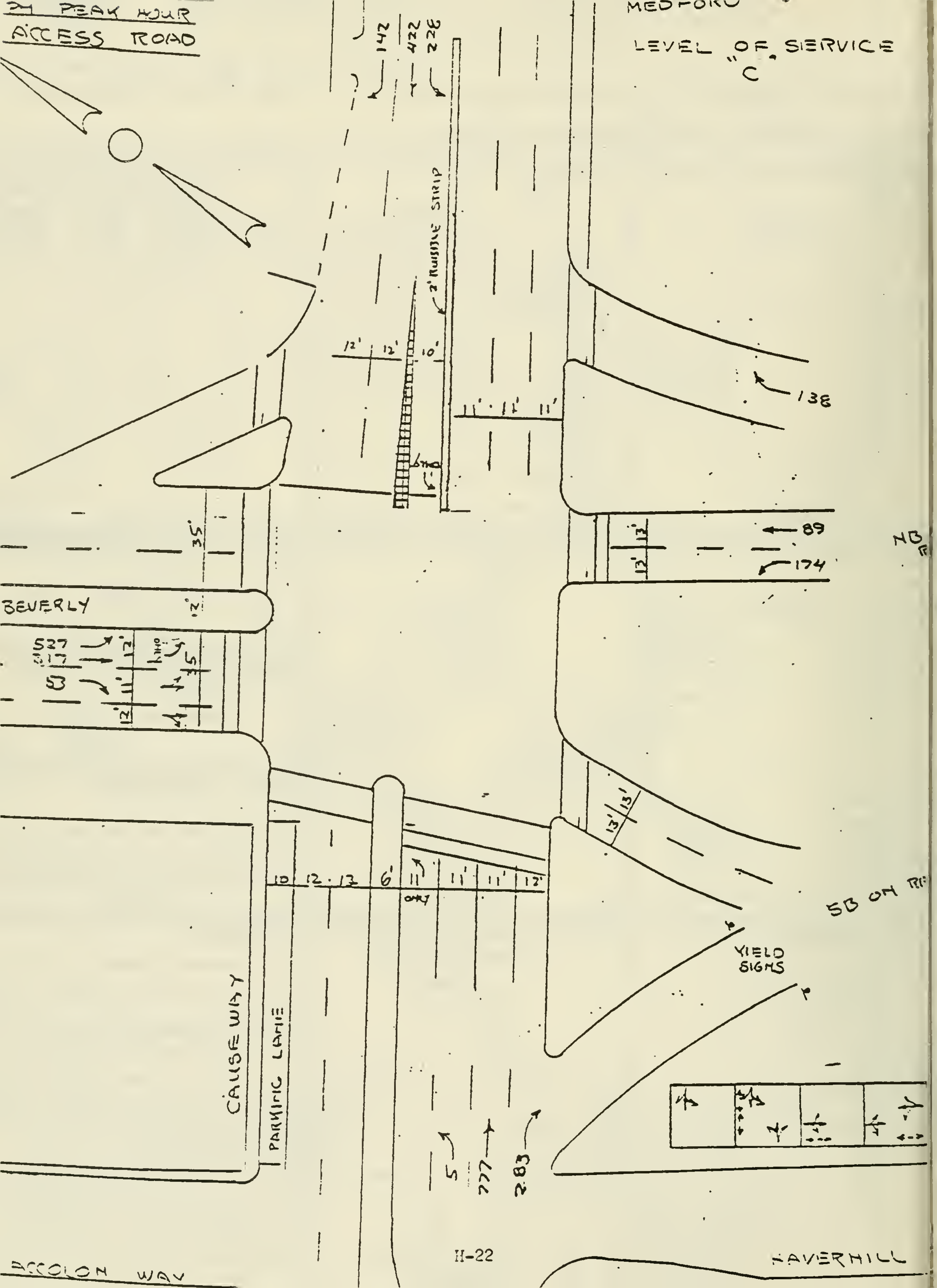
Step 9. Recalculate

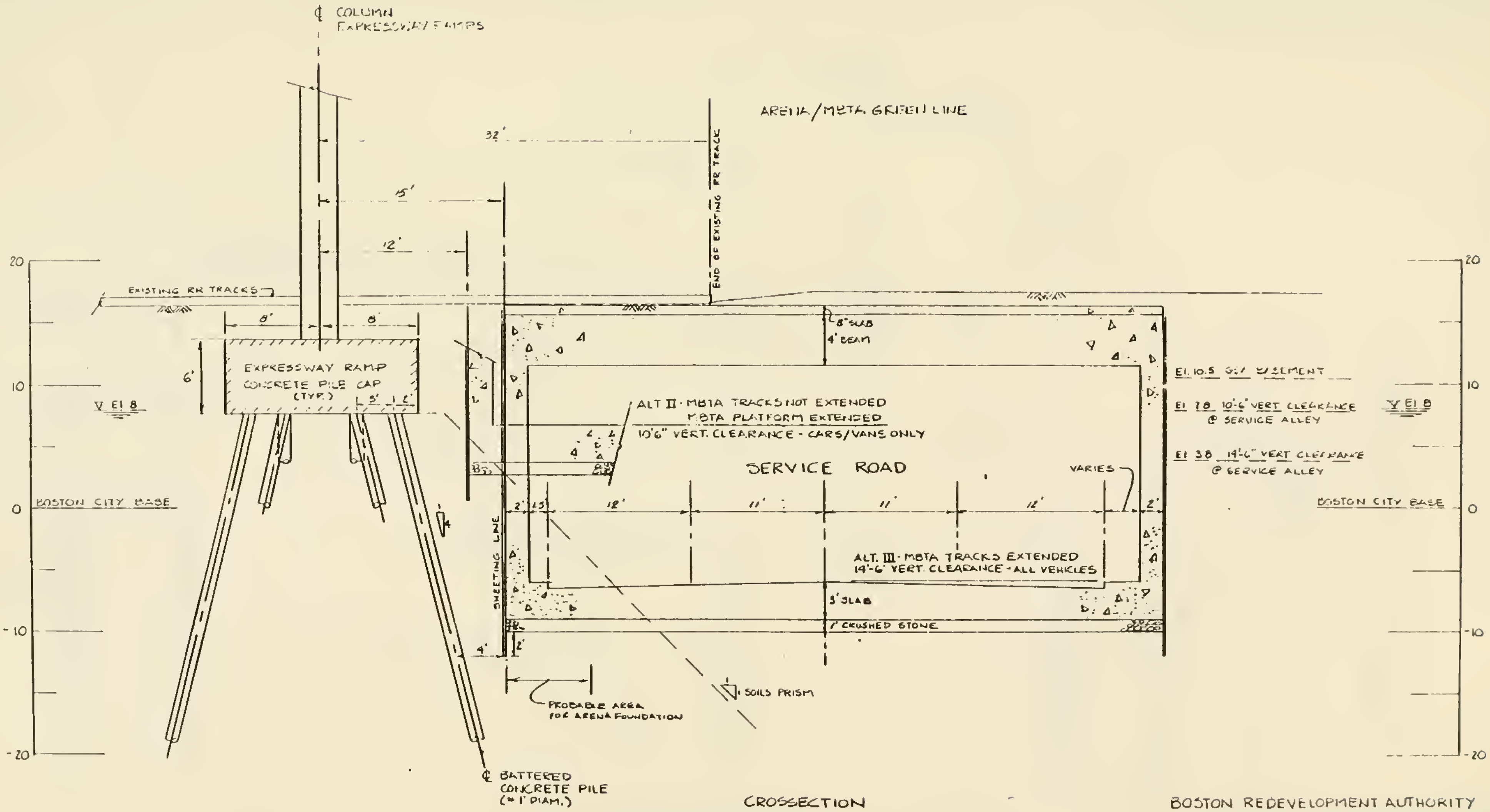
Geometric Change ____

Signal Change ____

Volume Change ____

Comments


PM PEAK HOUR
ACCESS ROAD
MEDFORD
LEVEL OF SERVICE "C"
2' RUMBLE STRIP
NB R
BEVERLY
SB ON R
YIELD SIGNS
ONLY
CAUSEWAY
PARKING LANE
HAVERHILL
ACCOLON WAY



CROSSECTION
SERVICE ROAD/EXPRESSWAY RAMP FOUNDATIONS
Scale · 1" = 8'

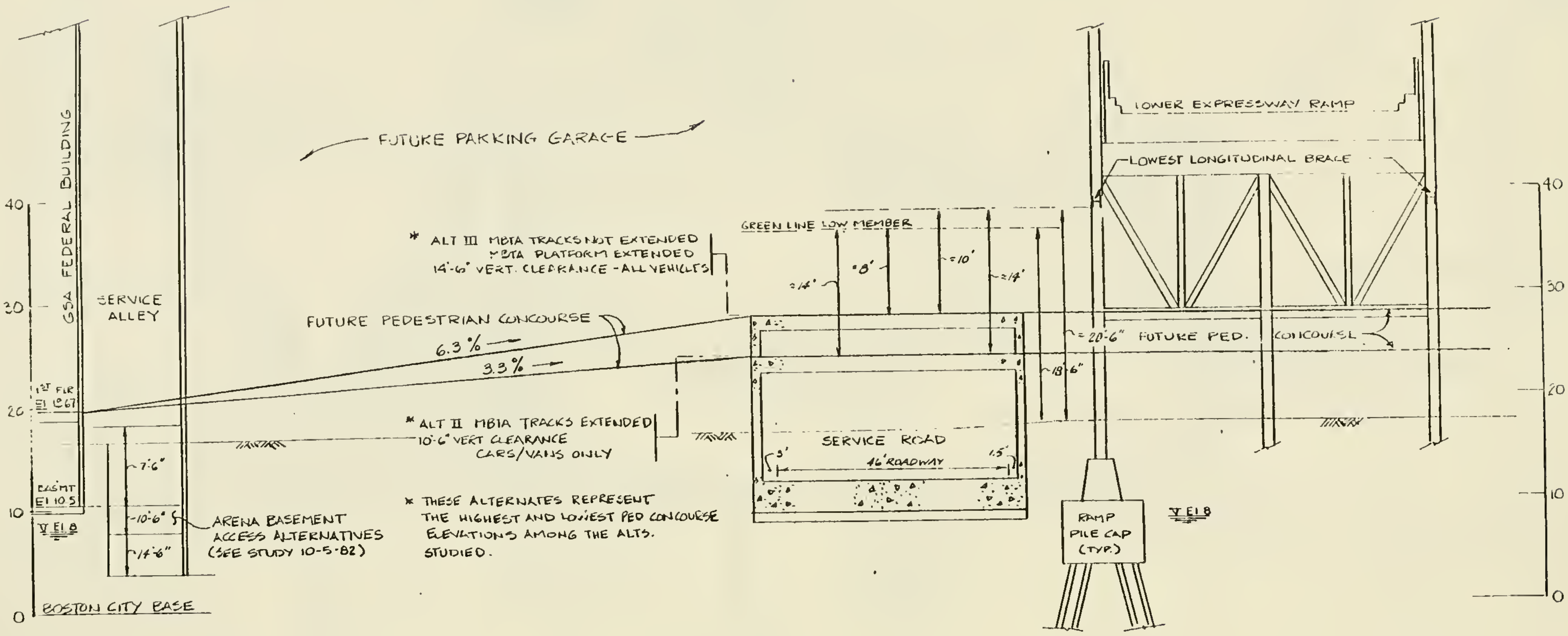
BOSTON REDEVELOPMENT AUTHORITY
SERVICE (ACCESS) ROAD FEASIBILITY STUDY
NASHUA ST. TO ACCOLON WAY/BEVERLY ST

FIGURE 1

MAGUIRE
Architects Engineers Planners
CE MAGUIRE INC Waltham Massachusetts

Subject
Job No

Sheet No of
Date
Computed
Checked


GSA FEDERAL BUILDING
SERVICE ALLEY
FUTURE PARKING GARAGE
1ST FLR EL 19.67
BASMT EL 10.5
∇ EL 8
BOSTON CITY BASE
7'-6"
10'-6"
14'-6"
ARENA BASEMENT ACCESS ALTERNATIVES (SEE STUDY 10-5-82)
FUTURE PEDESTRIAN CONCOURSE
6.3 %
3.3 %
* ALT III MBTA TRACKS NOT EXTENDED MBTA PLATFORM EXTENDED 14'-6" VERT. CLEARANCE - ALL VEHICLES
* ALT II MBTA TRACKS EXTENDED 10'-6" VERT CLEARANCE CARS/VANS ONLY
* THESE ALTERNATES REPRESENT THE HIGHEST AND LOWEST PED CONCOURSE ELEVATIONS AMONG THE ALTS. STUDIED.
GREEN LINE LOW MEMBER
≈14'
≈8'
≈10'
≈14'
SERVICE ROAD
46' ROADWAY
3'
1.5'
≈20'-6"
≈18'-6"
FUTURE PED. CONCOURSE
LOWER EXPRESSWAY RAMP
LOWEST LONGITUDINAL BRACE
RAMP PILE CAP (TYP.)
∇ EL 8
0
10
20
30
40

SERVICE ROAD/FUTURE PEDESTRIAN CONCOURSE
Scale Horz: 1" = 20'
Vert.: 1" = 10'

BOSTON REDEVELOPMENT AUTHORITY
SERVICE (ACCESS) ROAD FEASIBILITY STUDY
NASHUA ST. TO ACCOLON WAY/BEVERLY ST.

FIGURE 2

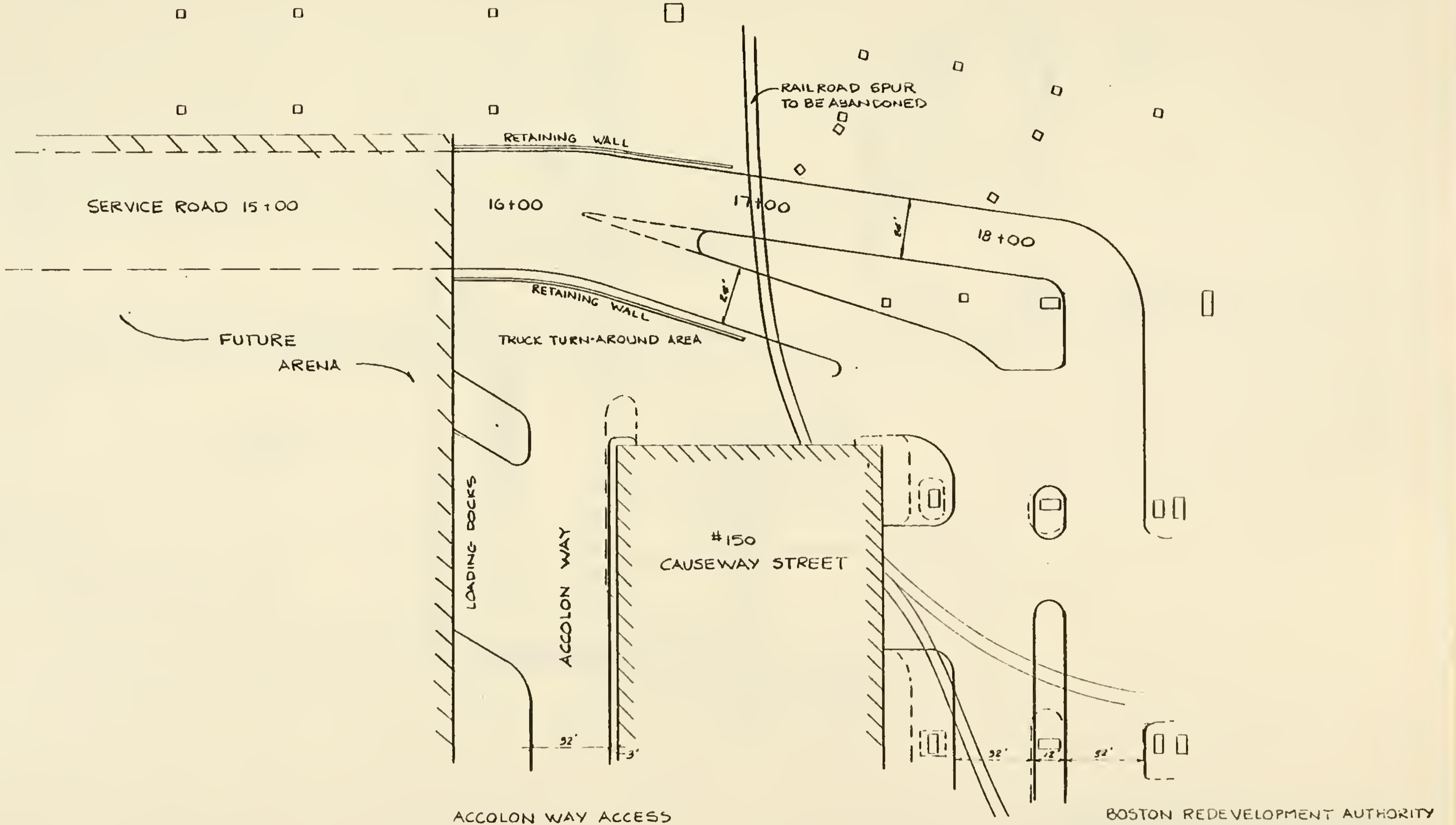
MAGUIRE
Architects Engineers Planners
C.E. MAGUIRE, INC. Waltham Massachusetts

Subject

Job No

Sheet No of
Date
Computed
Checked

Squares ¼ in scale 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60



ACCOLON WAY ACCESS
Scale: 1" = 40'

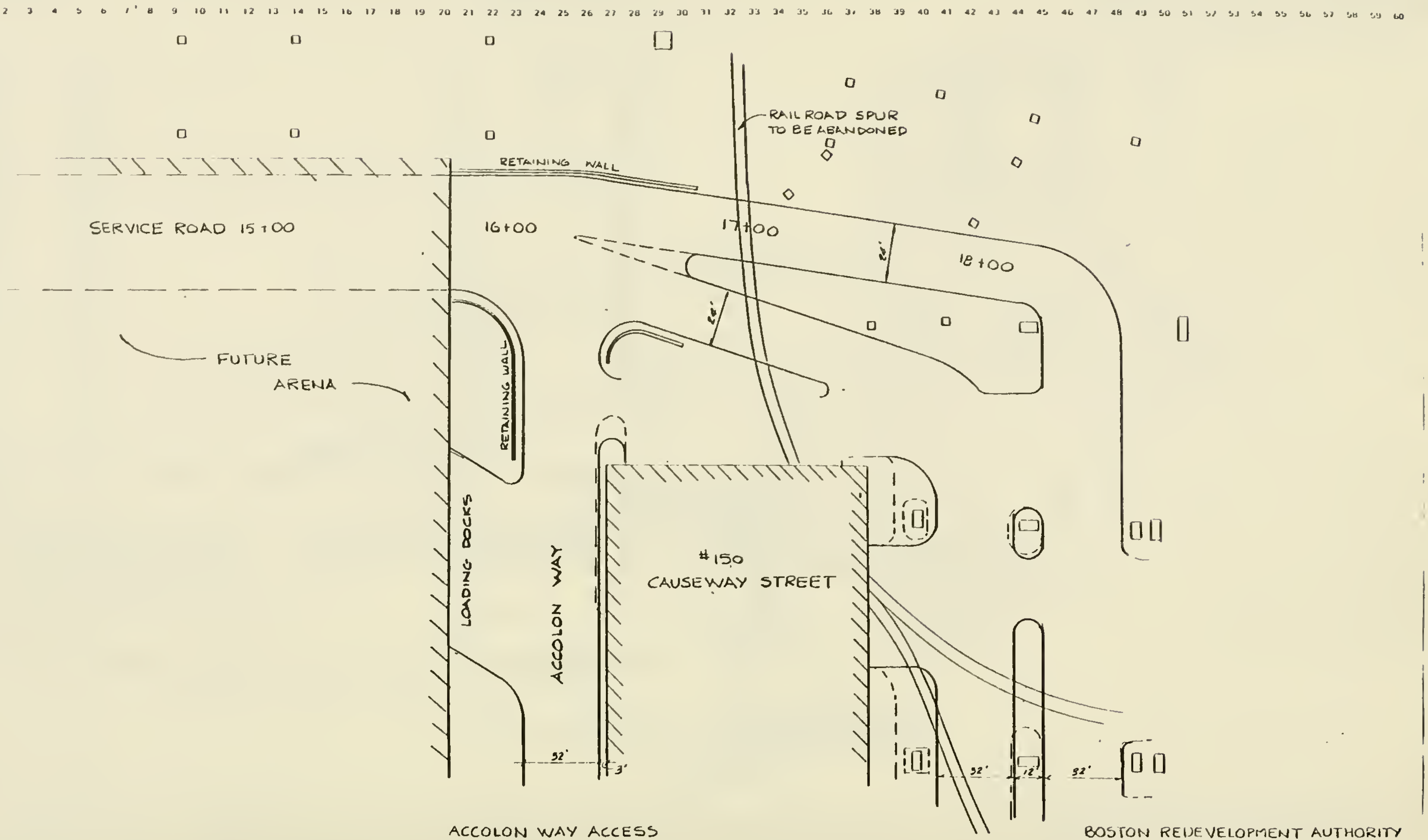
BOSTON REDEVELOPMENT AUTHORITY
SERVICE (ACCESS) ROAD FEASIBILITY STUDY
NASHUA ST. TO ACCOLON WAY/BEVERLY ST.

FIGURE 3

MAGUIRE
Architects Engineers Planners
CE MAGUIRE INC Waltham Massachusetts

Subject
Job No

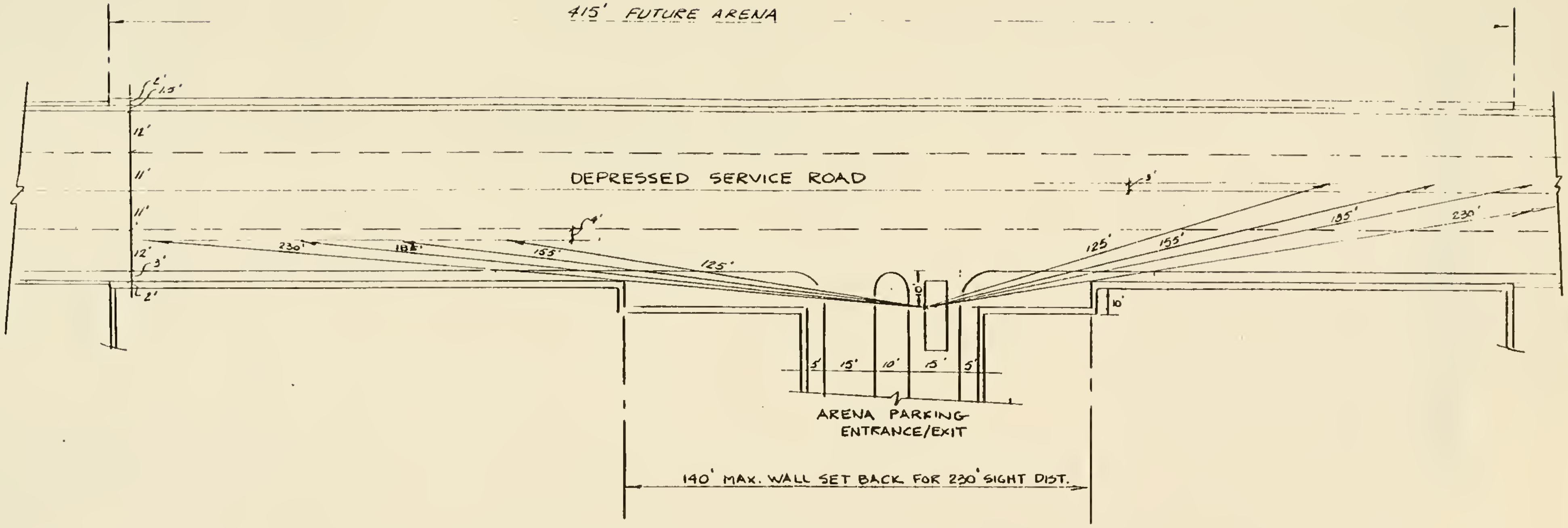
Sheet No of
Date
Computed
Checked



ACCOLON WAY ACCESS
Scale: 1" = 40'

BOSTON REDEVELOPMENT AUTHORITY
SERVICE (ACCESS) ROAD FEASIBILITY STUDY
NASHUA ST. TO ACCOLON WAY/BEVERLY ST.

FIGURE 4



SERVICE ROAD/ARENA PARKING ENTRANCE/EXIT
HORIZONTAL SIGHT DISTANCES
Scale: 1" • 30'

BOSTON REDEVELOPMENT AUTHORITY
SERVICE (ACCESS) ROAD FEASIBILITY STUDY
NASHUA ST TO ACCOLON WAY/BEVERLY ST

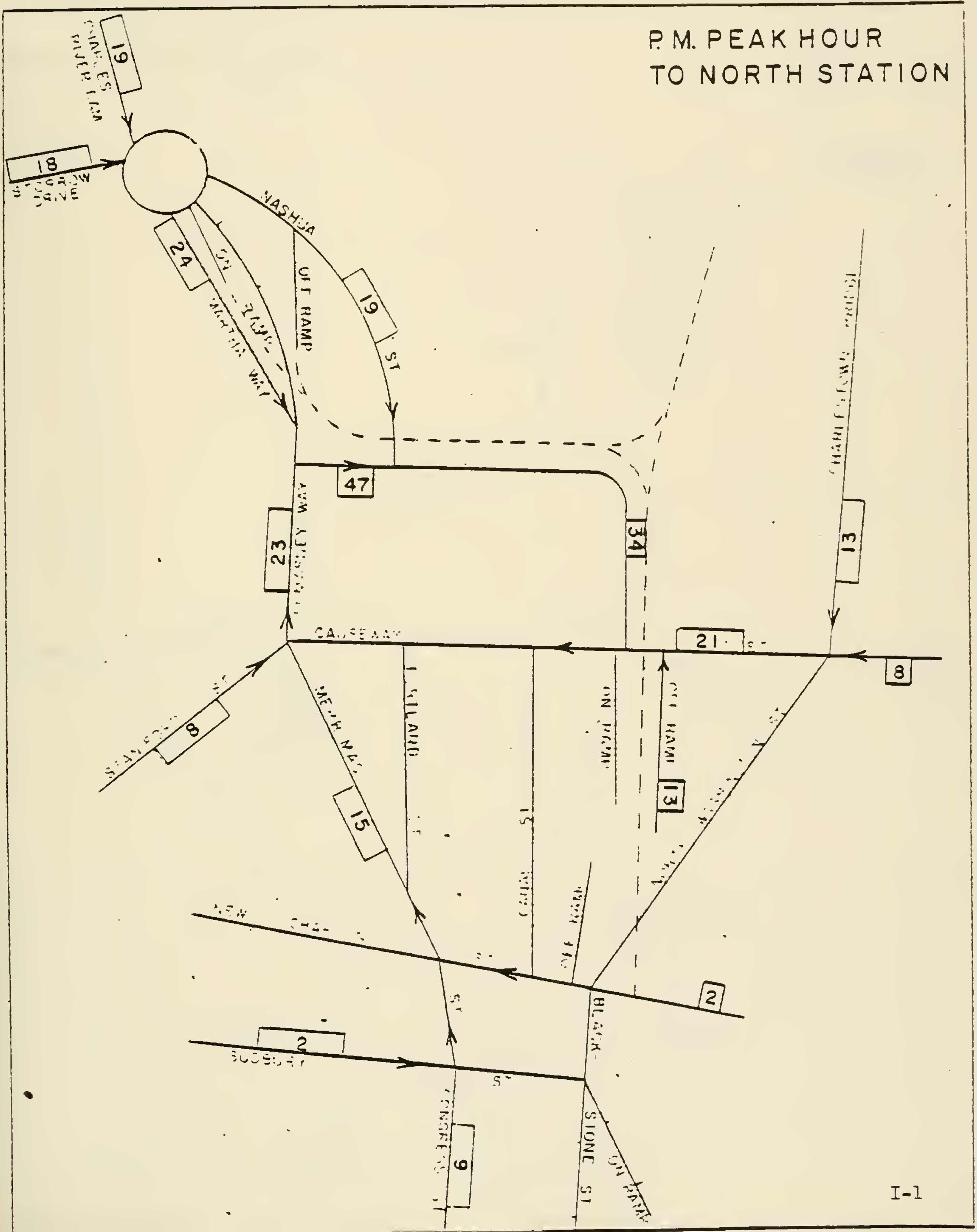
FIGURE 5

Appendix I P.M. PEAK-HOUR TRAFFIC ASSIGNMENTS

FIGURE I-1

PERCENTAGE TRAFFIC ASSIGNMENTS

PHASE I



P.M. PEAK HOUR TO NORTH STATION

FIGURE I-2

PERCENTAGE TRAFFIC ASSIGNMENTS

PHASE I

P.M. PEAK HOUR
FROM NORTH STATION

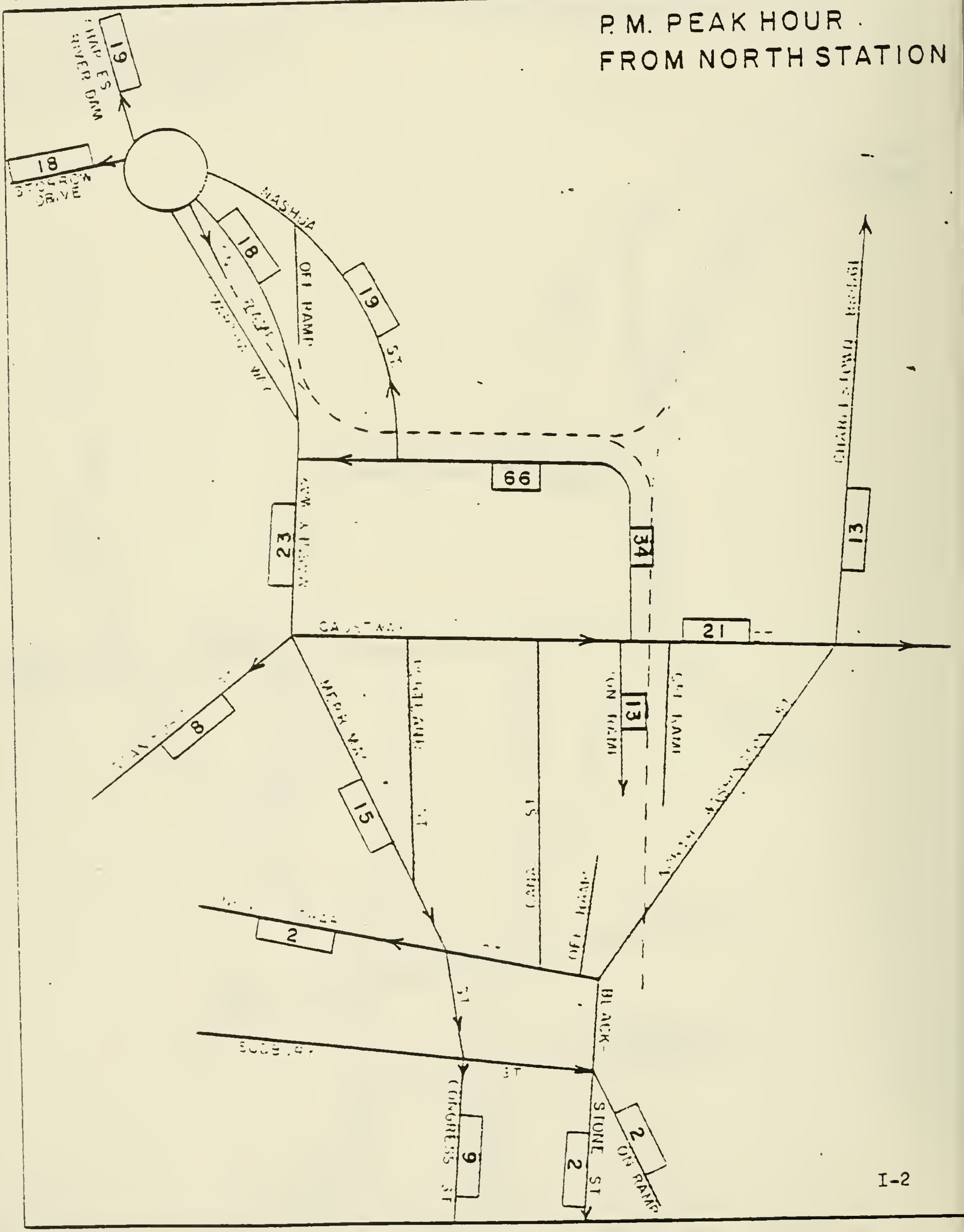


FIGURE I-3

PERCENTAGE TRAFFIC ASSIGNMENTS

PHASE II

P.M. PEAK HOUR
TO NORTH STATION

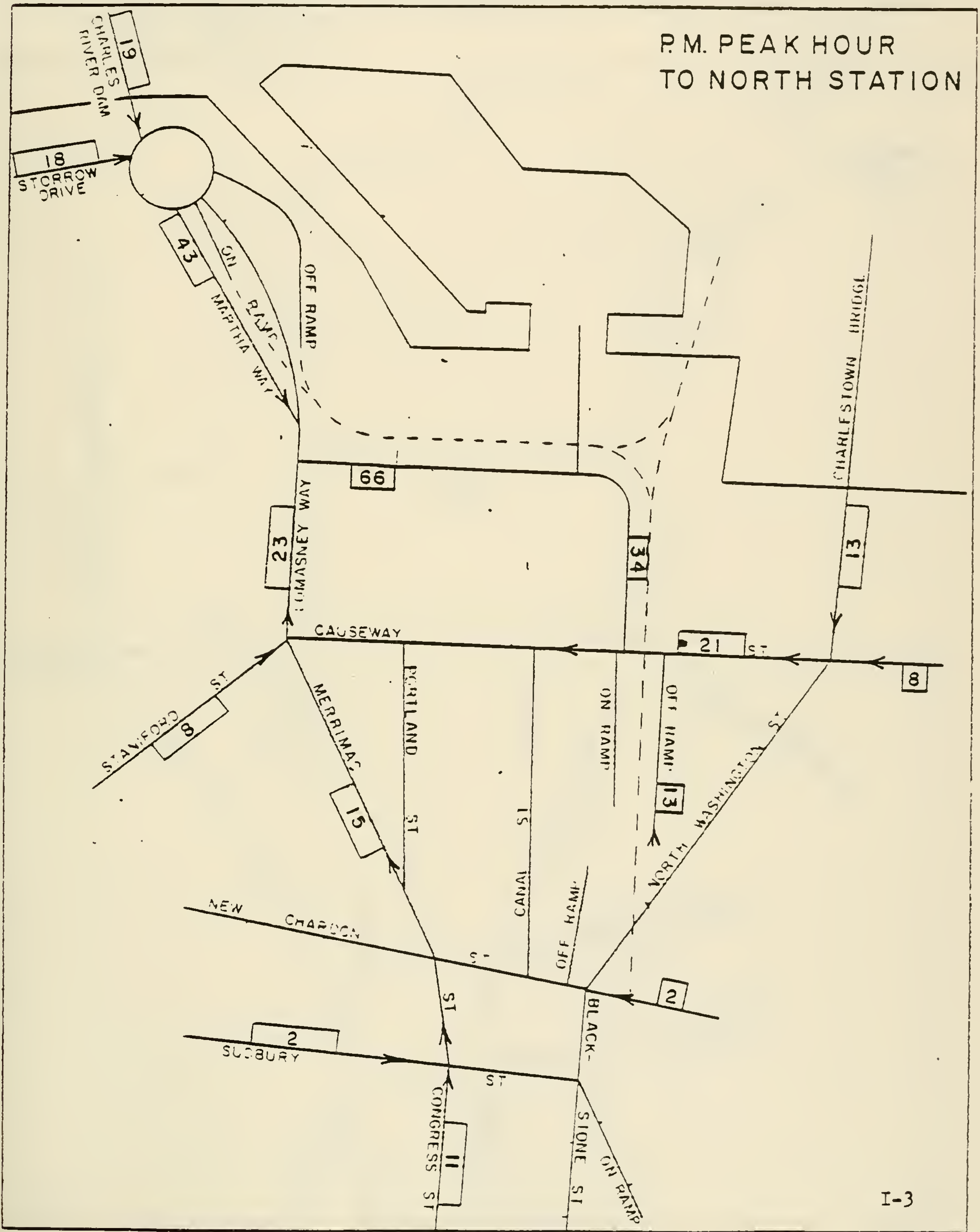


FIGURE I-4

PERCENTAGE TRAFFIC ASSIGNMENTS

PHASE II

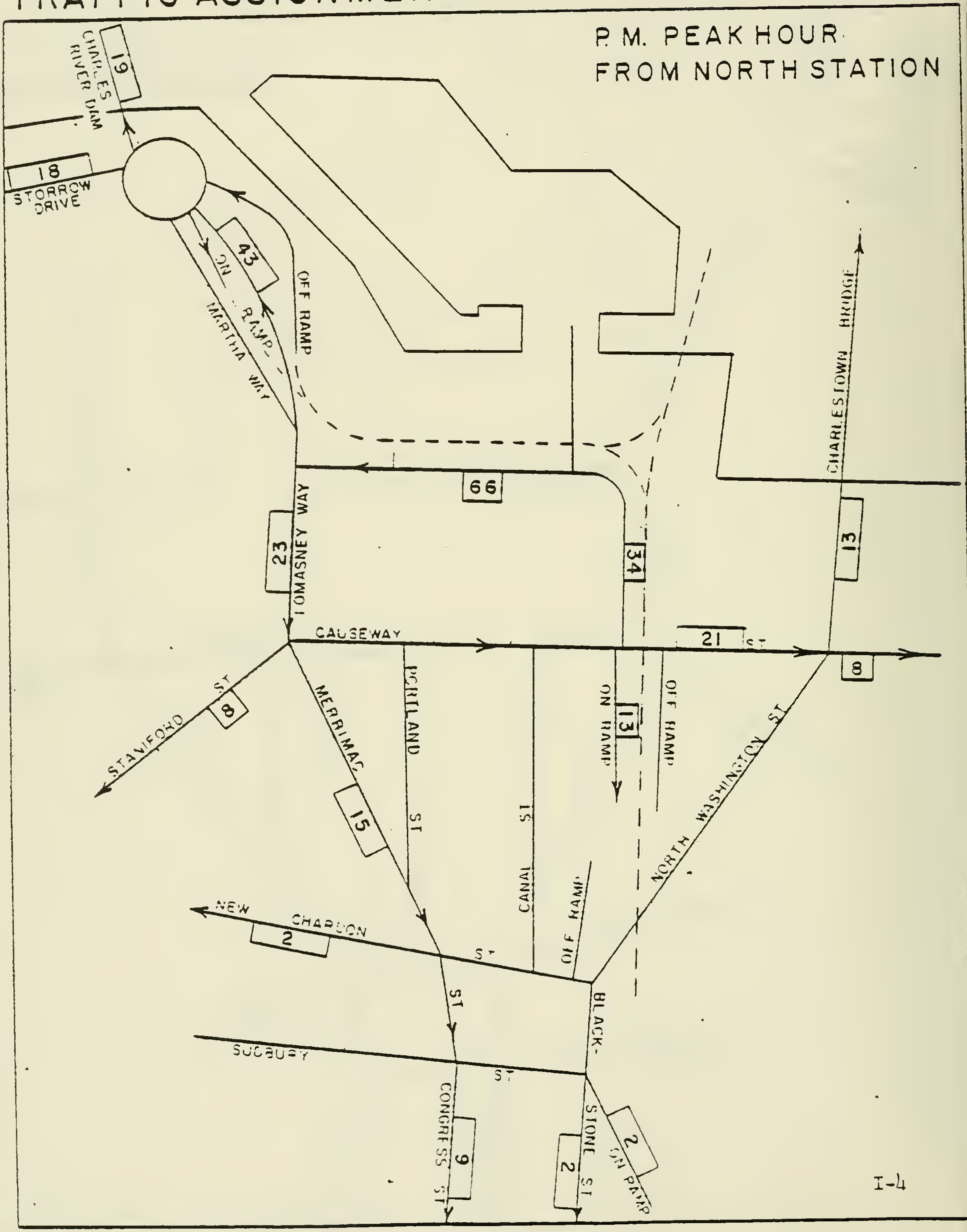


FIGURE I-5

TRAFFIC ASSIGNMENTS NORTH STATION

PHASE I 1987

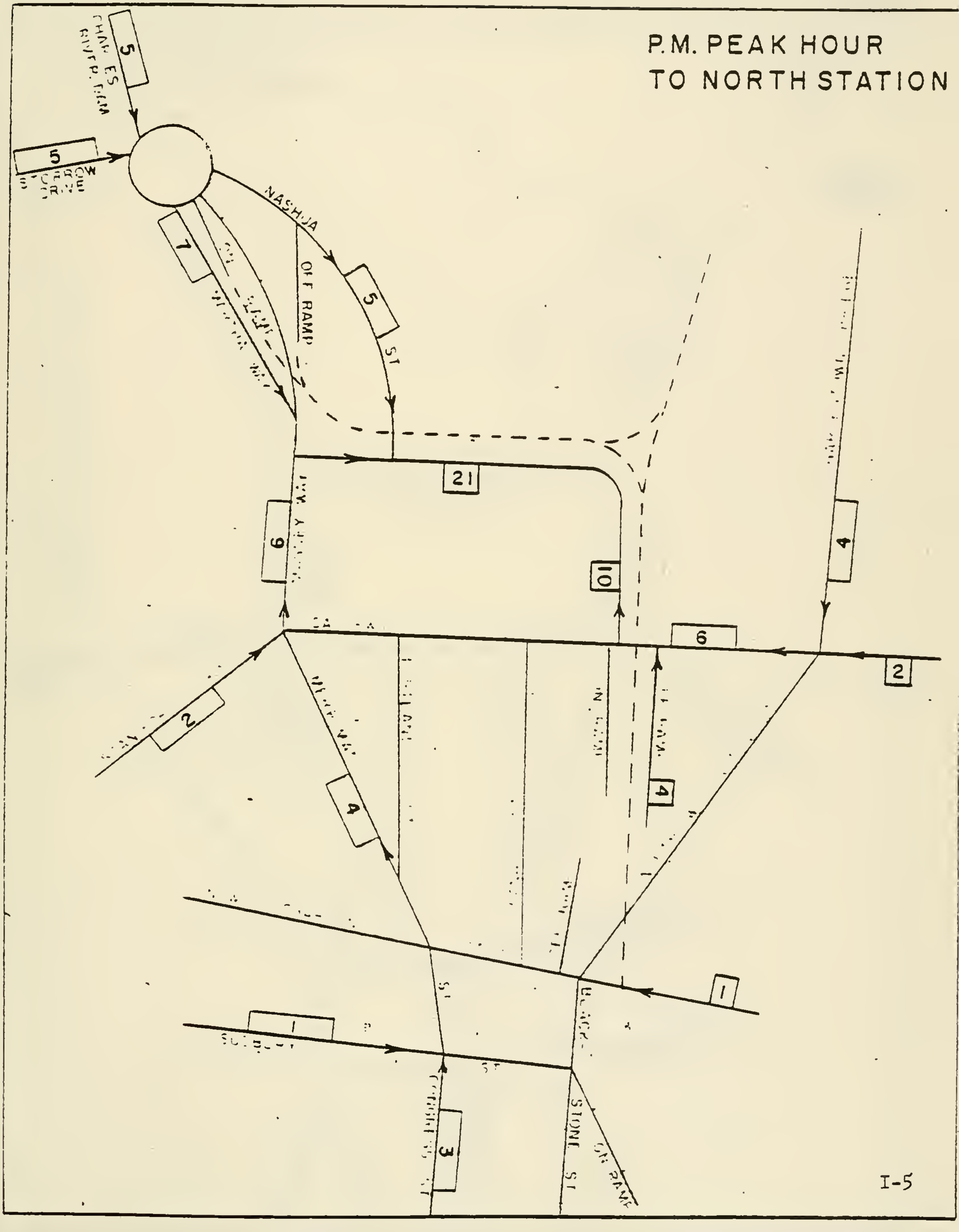
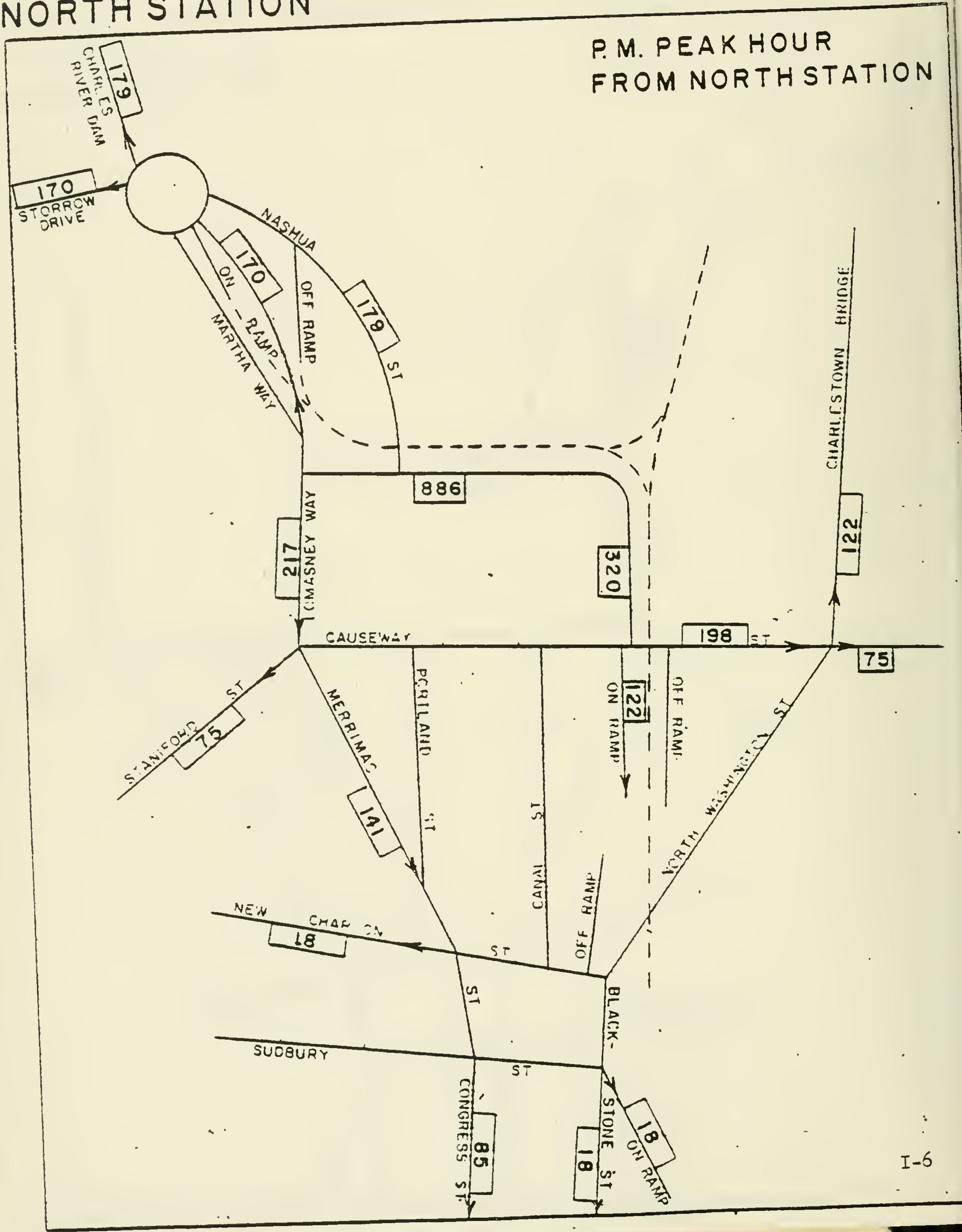

P.M. PEAK HOUR
TO NORTH STATION

FIGURE I-6

TRAFFIC ASSIGNMENTS NORTH STATION

PHASE I 1987



P.M. PEAK HOUR
FROM NORTH STATION

FIGURE I-7

TRAFFIC ASSIGNMENTS NORTH STATION

PHASE II 2000 PREFERRED PROGRAM

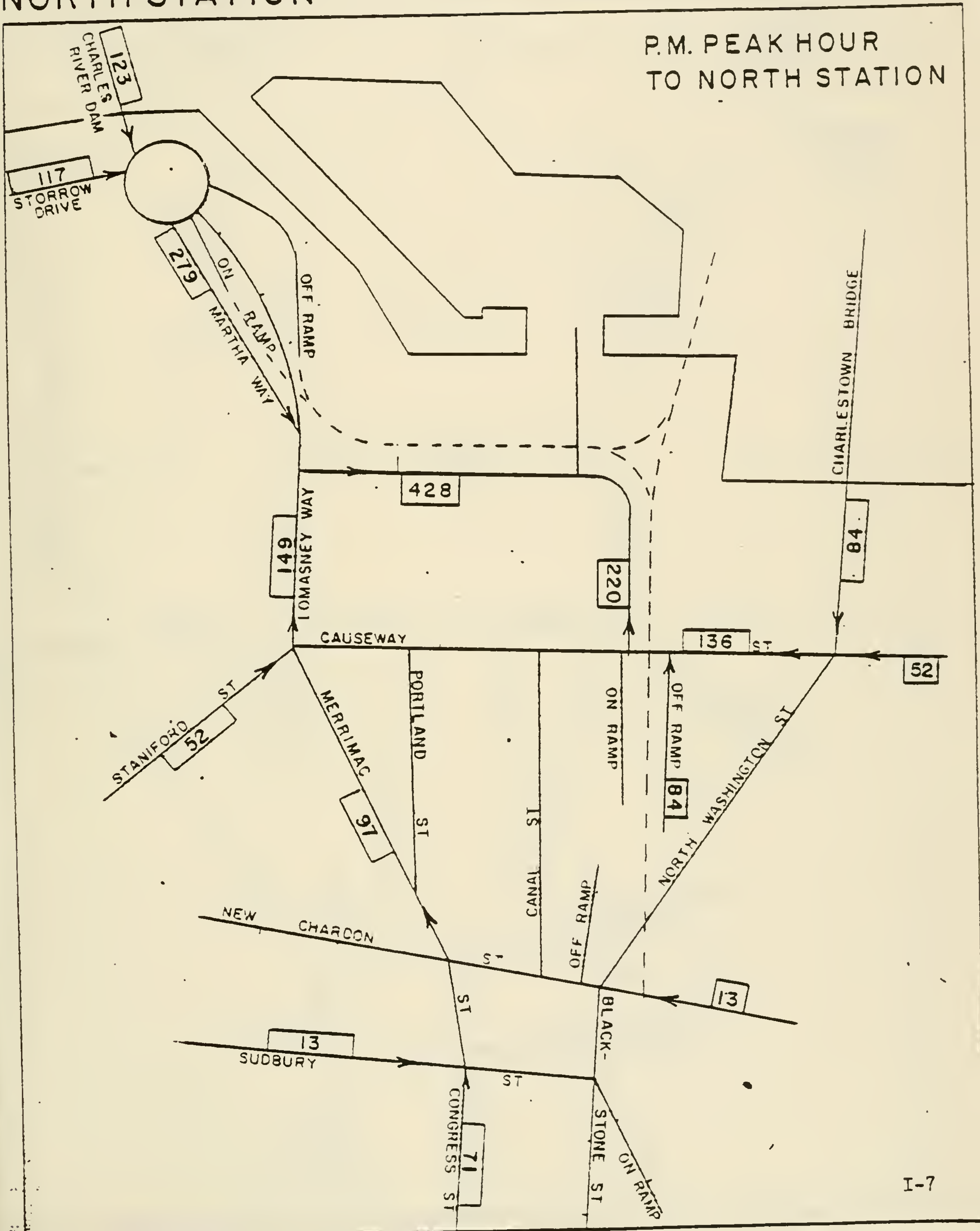


FIGURE I-8

TRAFFIC ASSIGNMENTS
NORTH STATION

PHASE II 200
PREFERRED PROGRA

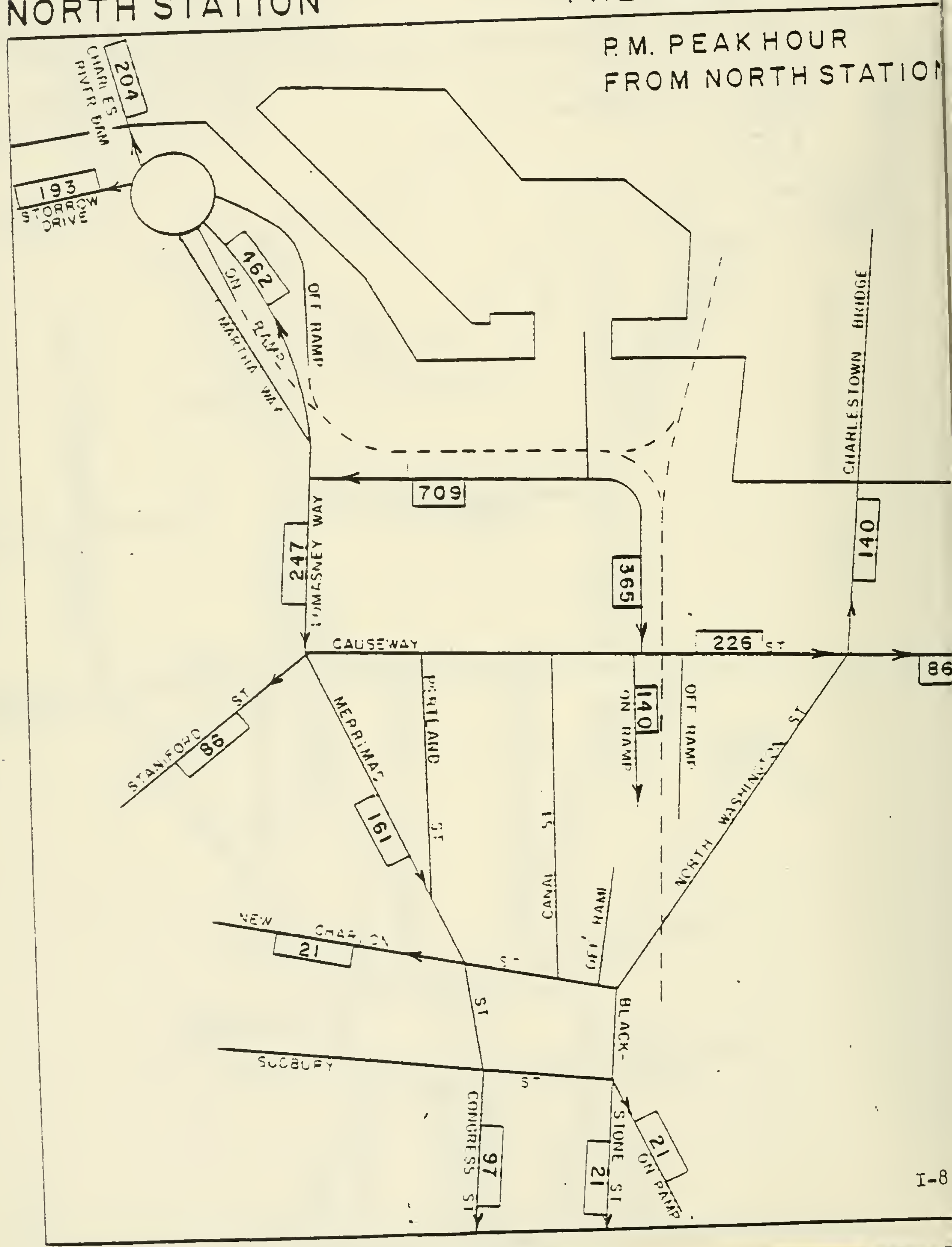


FIGURE I-9

TRAFFIC ASSIGNMENTS NORTH STATION

PHASE II 2000 OPTIONAL PROGRAM

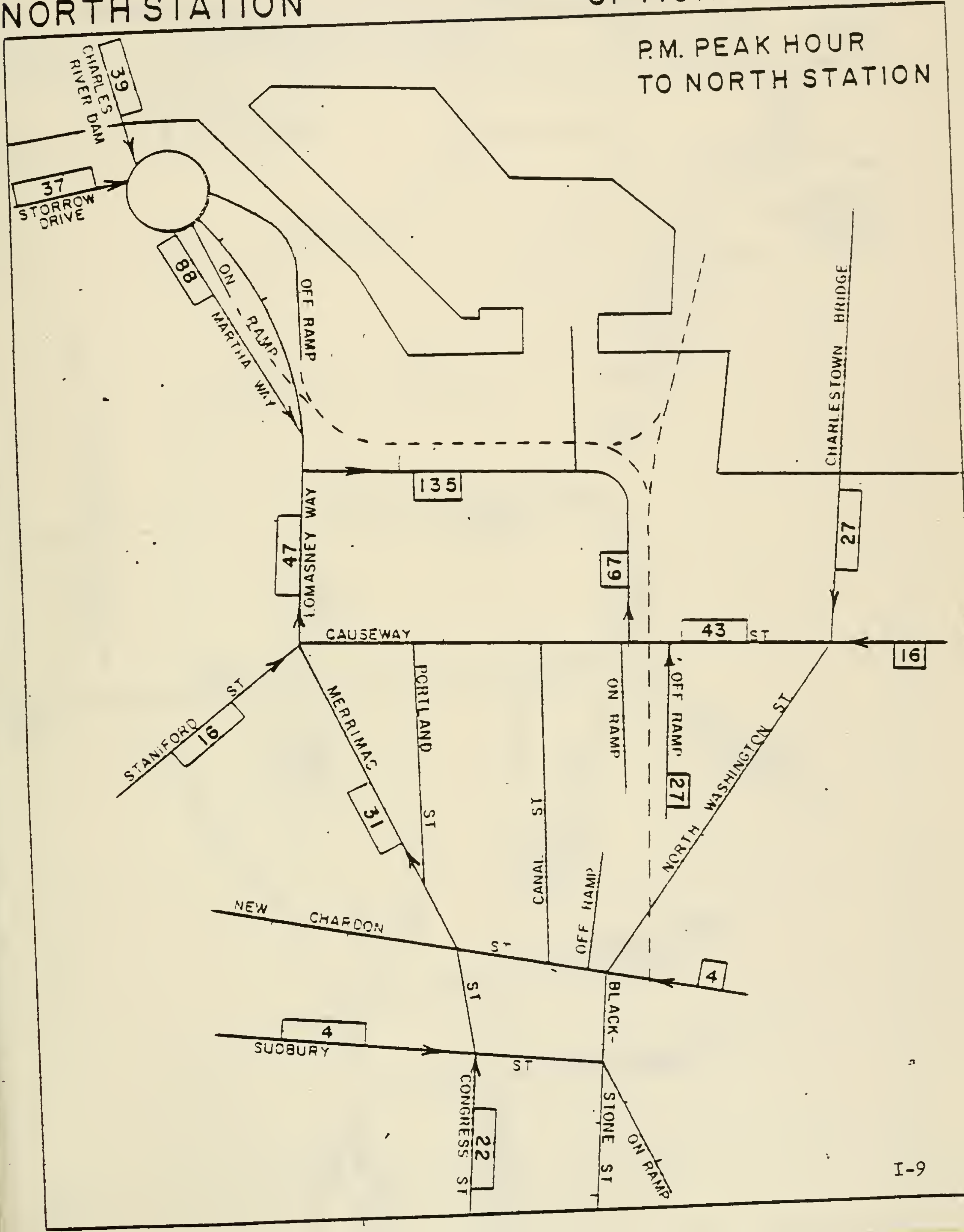
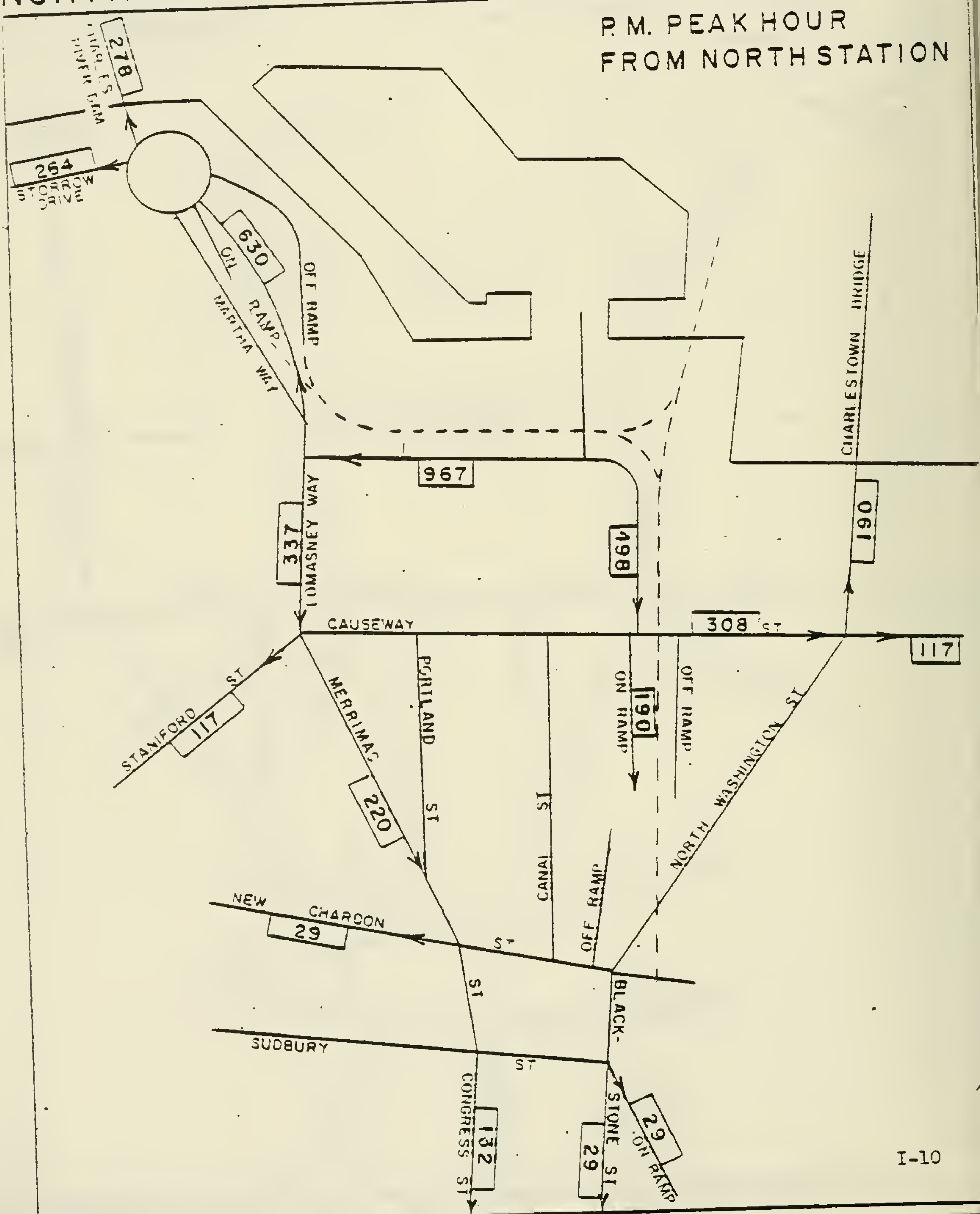


FIGURE I-10

TRAFFIC ASSIGNMENTS NORTH STATION

PHASE II 2000 OPTIONAL PROGRAM

P.M. PEAK HOUR
FROM NORTH STATION



Appendix J GREEN LINE ELEVATED RELOCATION OPTIONS: SUMMARY DESCRIPTION OF ALTERNATIVES AND ENVIRONMENTAL CONSEQUENCES

APPENDIX J: GREEN LINE ELEVATED RELOCATIION OPTIONS

SUMMARY DESCRIPTION OF ALTERNATIVES AND ENVIRONMENTAL CONSEQUENCES*

4. Green Line Elevated Relocation

4.1 Background

A major proposal of the North Station Urban Renewal Plan is the demolition of the existing Green Line elevated structure on Causeway Street/Lomasney Way and its replacement by an alternative facility in the environs of North Station. For many years, the Green Line elevated structure has been perceived as a physical and environmental barrier which has contributed strongly to the deterioration of the North Station area and which has inhibited redevelopment actions. The desire to eliminate this elevated structure also has existed for a long time, but serious action on its removal did not occur due partly to a lack of serious and committed land use plans for the area and in part because of the greater attention having been given to the reconstruction of major roadway links in the general area, related to the Central Artery.

Now that a bold concept for the renewal of the North Station area has been adopted and the approval of an urban renewal plan has been requested, the impetus for achieving a Green Line relocation exists. In fact, the BRA has concluded (as has Moshie Safdie, the Authority's consultant in preparing the renewal plan) that without such relocation, redevelopment plans would not succeed.

The North Station area Green Line relocation project involves an approximate 3,700 foot section of the Green Line between Haymarket and Science Park Station (see Figure 30). Within this section is the North Station stop, which, in addition to servicing the surrounding area, also serves as a modal transfer point for commuter rail patrons. The existing section comprises about 800 feet of transition from subway at Haymarket to elevated at North Station and approximately 2,900 feet of elevated viaduct. The line now serves about 660 light rail cars per day.

4.2 Description of Alternatives

As part of the scope for this Environmental Impact Report, the Executive Office of Environmental Affairs, in consultation with the BRA and the MBTA, identified eight Green Line relocation alternatives for consideration. These alternatives,

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* From Part VI.A.4 (pp 142-157) of North Station Urban Renewal Project, Interim Environmental Impact Report, Boston Redevelopment Authority, August 29, 1980 (Tables 39 and 40 revised in accordance with MBTA comments), with additions from Appendix G of the Interim EIR.

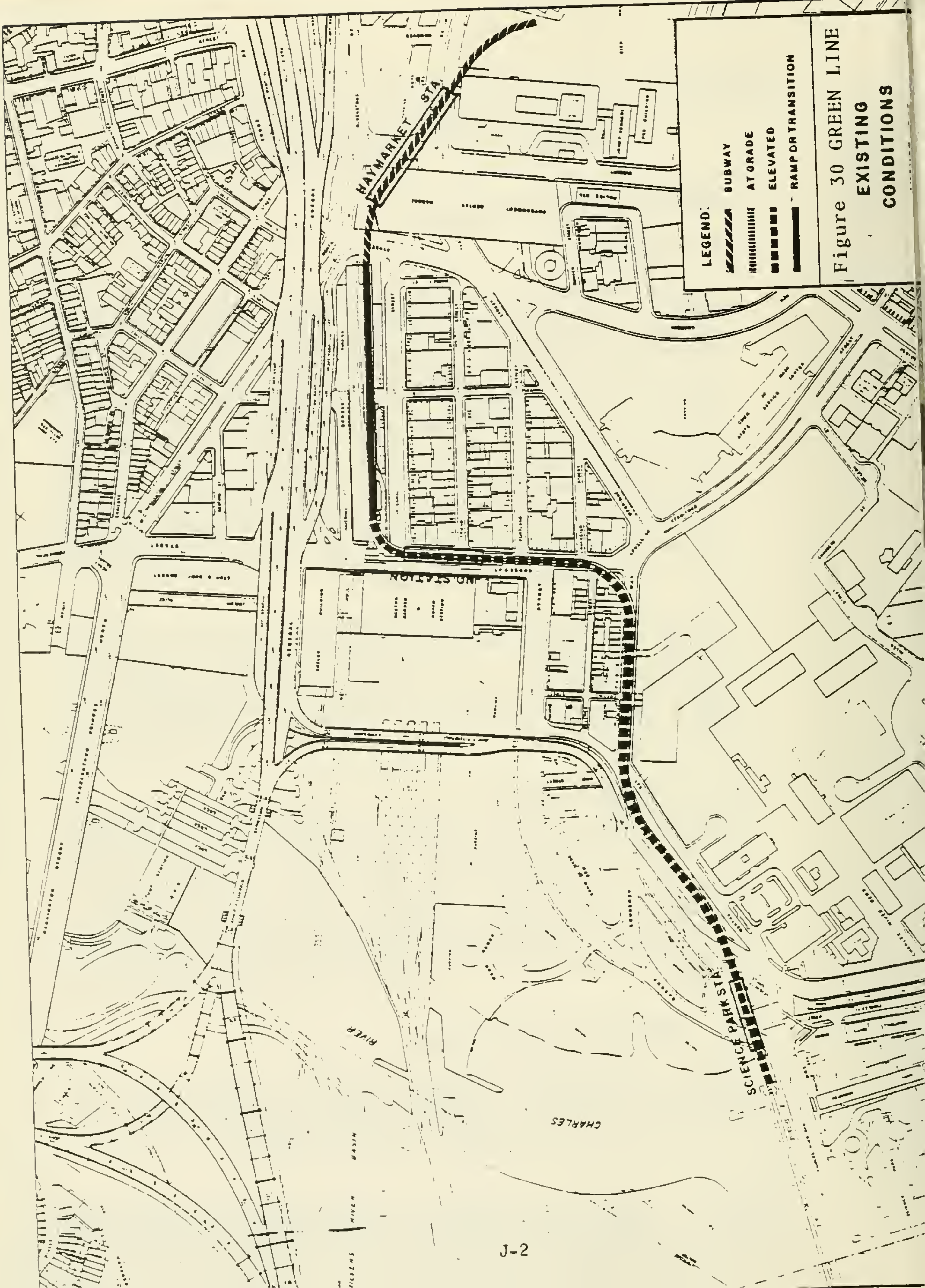

Figure 30 GREEN LINE EXISTING CONDITIONS

summarized below, are described in greater detail, together with a comprehensive evaluation of their feasibility with respect to specific design determents and of their environmental consequences in Appendix G.*

1. No Build Alternative

   The No-Build Alternative is the no-action base condition which is assessed for comparison purposes. It allows for the continuation of Green Line service by means of the existing elevated structure, with no improvements. The present North Station station is located above Causeway Street in front of the Boston Garden building; there is also an at-grade terminal station between Canal and Haverhill Streets.

2. At-Grade Relocation

   This alternative provides for an at-grade track between the subway at Haymarket Station and the elevated structure at Science Park. Three optional horizontal elements are associated with this alternative: (a) the existing alignment along Causeway Street and Lomasney Way, (b) an alignment behind North Station via Accolon Way, and (c) through the Bulfinch Triangle area on Traverse Street, turning onto Merrimac Street and continuing to Lomasney Way. Station locations vary according to alignment option. Under option (a) the station would occur on Causeway Street, under option (b), behind North Station at the commuter rail terminus, and with the Traverse Street route, at Lomasney Way south of the transition section.

3. Relocated Elevated Structure

   Alternative #3 provides for a new elevated structure to be built north of the Boston Garden building, above the MBTA commuter rail tracks and along the Storrow Drive connector ramps. From Haymarket Station, the alignment would rise to cross above Causeway Street and Accolon Way and would join the existing elevated structure in the vicinity of Martha Road. The station location would be to the north of the Garden building, above the commuter rail tracks and adjacent to the highway ramp structures.

4. Subway under Existing Alignment

   This alternative would provide for the construction of a subway section beneath the existing elevated alignment on Causeway Street and Lomasney Way, rising in a transition section adjacent to Martha Road to rejoin the existing Green Line structure at Science Park Station. The station associated with this option would be located below-grade directly beneath its present Causeway Street location.

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* Appendix G is found in the North Station Urban Renewal Project, Interim Environmental Impact Report, Boston Redevelopment Authority, August 29, 1980.

5. Subway under Boston Garden

Alternative #5 includes a below-grade alignment extending from Haymarket Station, parallel to Canal Street and passing beneath the Boston Garden building to a transition section adjacent to Martha Road. An optional alignment would pass below a portion of the Bulfinch Triangle and the Madison Hotel site to join the Martha Road vertical transition section and the elevated structure south of Science Park Station. The station would be located directly beneath Boston Garden in the case of the first option, and below the Madison Hotel under option #2.

6. Subway to Cambridge

This subway alternative provides the option of a new subway tunnel under the Charles River, replacing the existing Charles River Dam viaduct. The alignment remains below grade from Haymarket Station, passing under the Charles to Lechmere Station in Cambridge. The station would be directly below Boston Garden, accessible to the Orange Line, commuter rail, and the development area.

7. Merrimac Street/Lomasney Way Subway

This alternative provides for a subway extending from Haymarket Station along one of two optional routes to Merrimac Street and Lomasney Way, rising to an overhead profile linking to the existing elevated structure south of Science Park Station. Option #1 for the horizontal alignment would continue north from Haymarket Station turning beneath Traverse Street to Merrimac Street. Alignment option #2 would turn, to meet Merrimac Street, at a point south of the existing Haymarket Station, requiring a reconstruction of the present station. The North Station stop would be located below Lomasney Way at the western boundary of the project area.

8. Replacement Bus Service

The final alternative would eliminate all Green Line transit service between North Station and Lechmere Station in Cambridge, making North Station a Green Line terminus. The transit service would be replaced by buses from the portions of Cambridge and Somerville within the Green Line service area, which would arise at North Station for transfer to other modes.

FIGURE 10

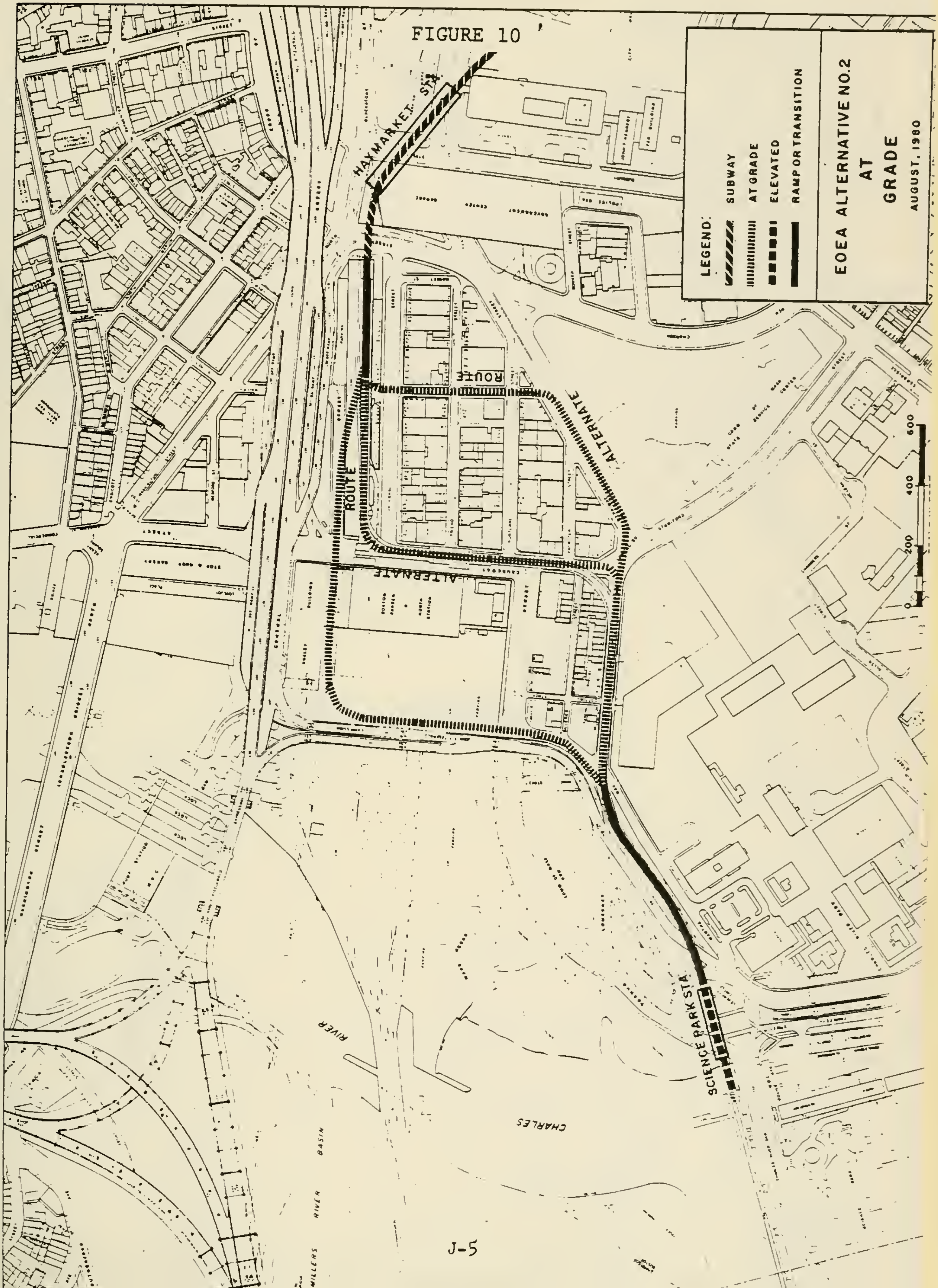

LEGEND:
SUBWAY
AT GRADE
ELEVATED
RAMP OR TRANSITION
EOEA ALTERNATIVE NO.2
AT
GRADE
AUGUST, 1980
HAYMARKET STA
SCIENCE PARK STA
ROUTE
ALTERNATE
ROUTE
ALTERNATE
CHARLES
RIVER
MILLERS
RIVER
BASIN
0
200
400
600

FIGURE 11

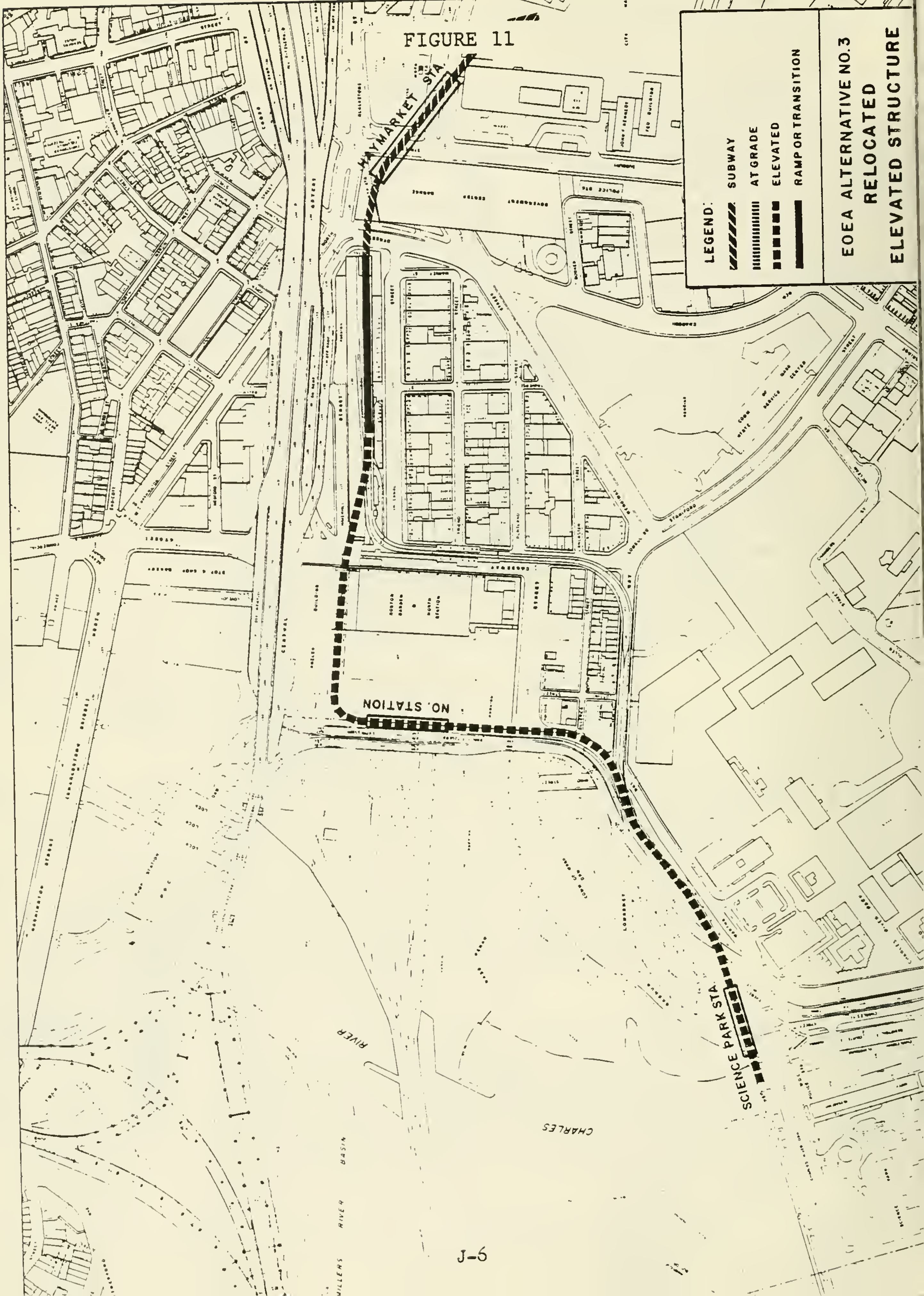
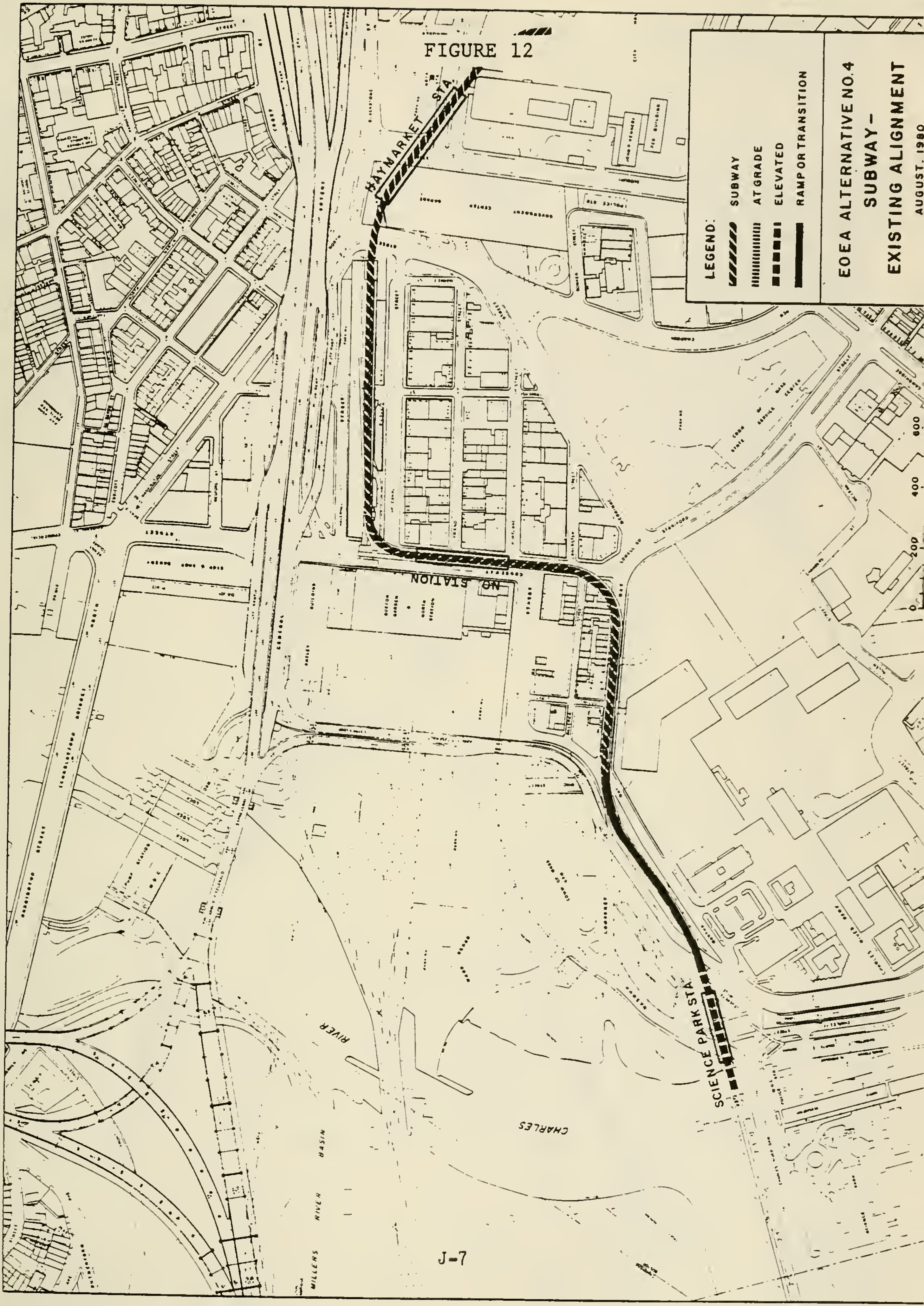
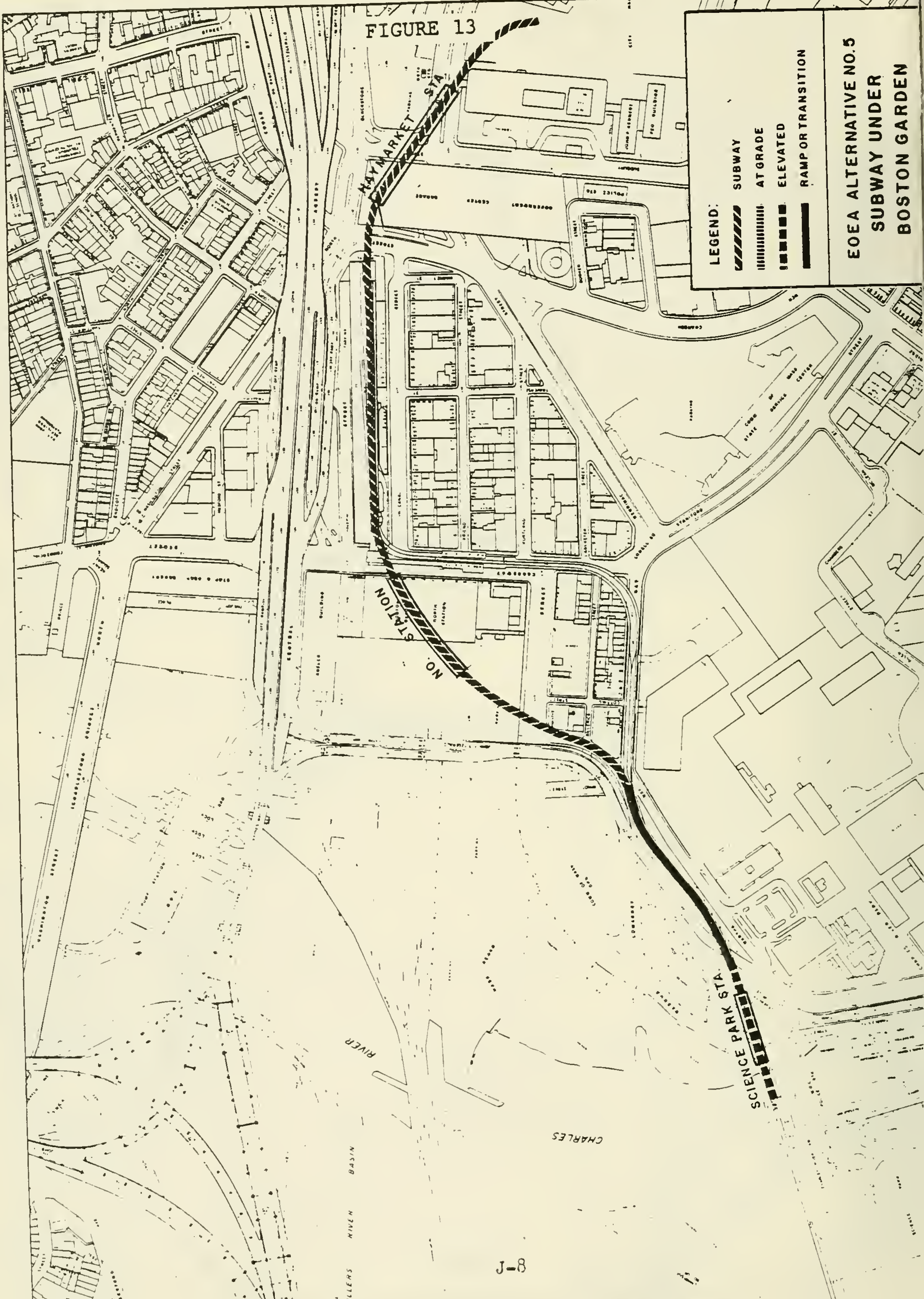

LEGEND:
SUBWAY
AT GRADE
ELEVATED
RAMP OR TRANSITION
EOEA ALTERNATIVE NO.3
RELOCATED
ELEVATED STRUCTURE
HAYMARKET STA.
NO. STATION
SCIENCE PARK STA.
CHARLES
RIVER
BASIN

FIGURE 12



EOEA ALTERNATIVE NO.4
SUBWAY—
EXISTING ALIGNMENT
AUGUST, 1980

FIGURE 13



EOEA ALTERNATIVE NO.5
SUBWAY UNDER
BOSTON GARDEN

FIGURE 14

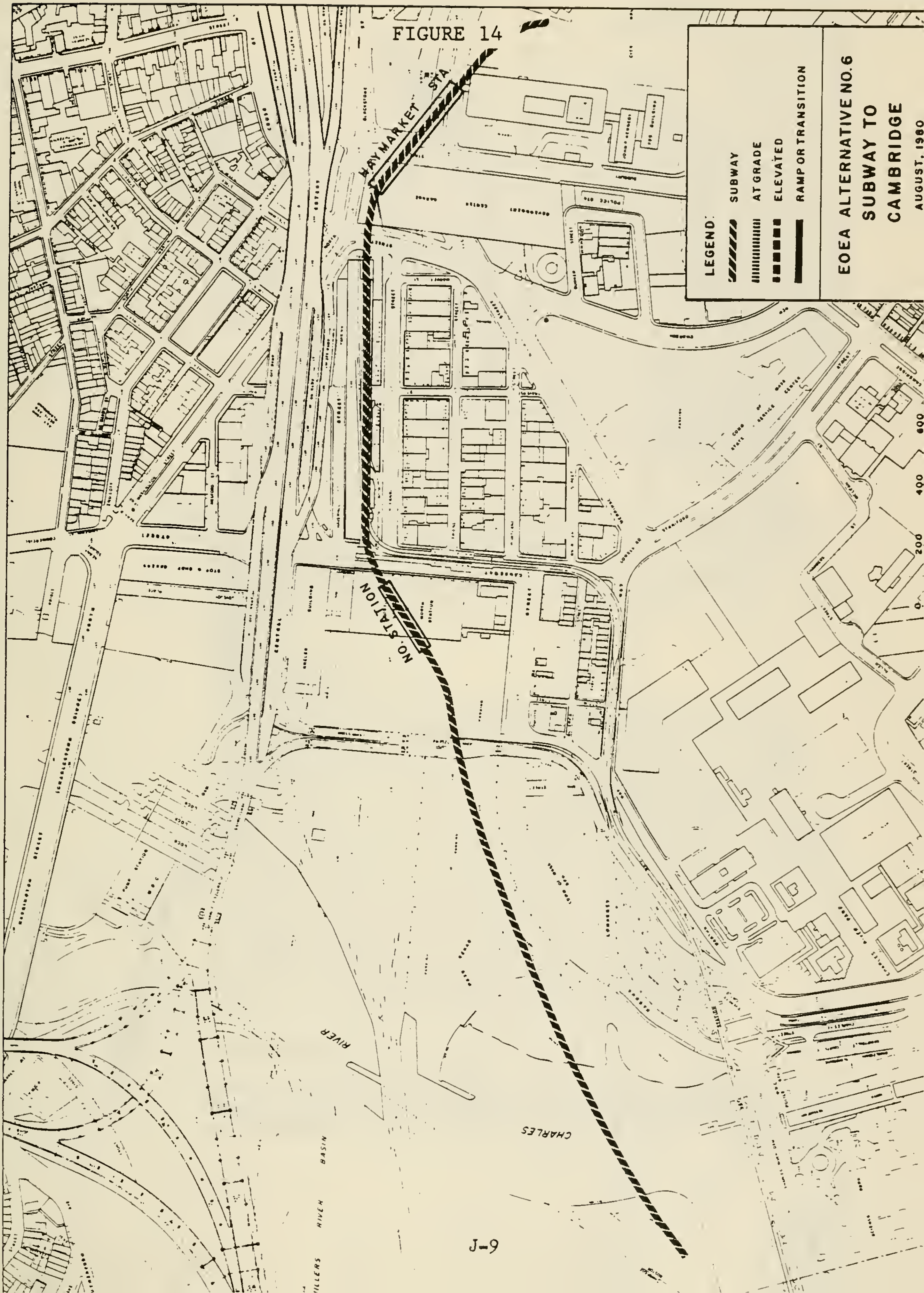
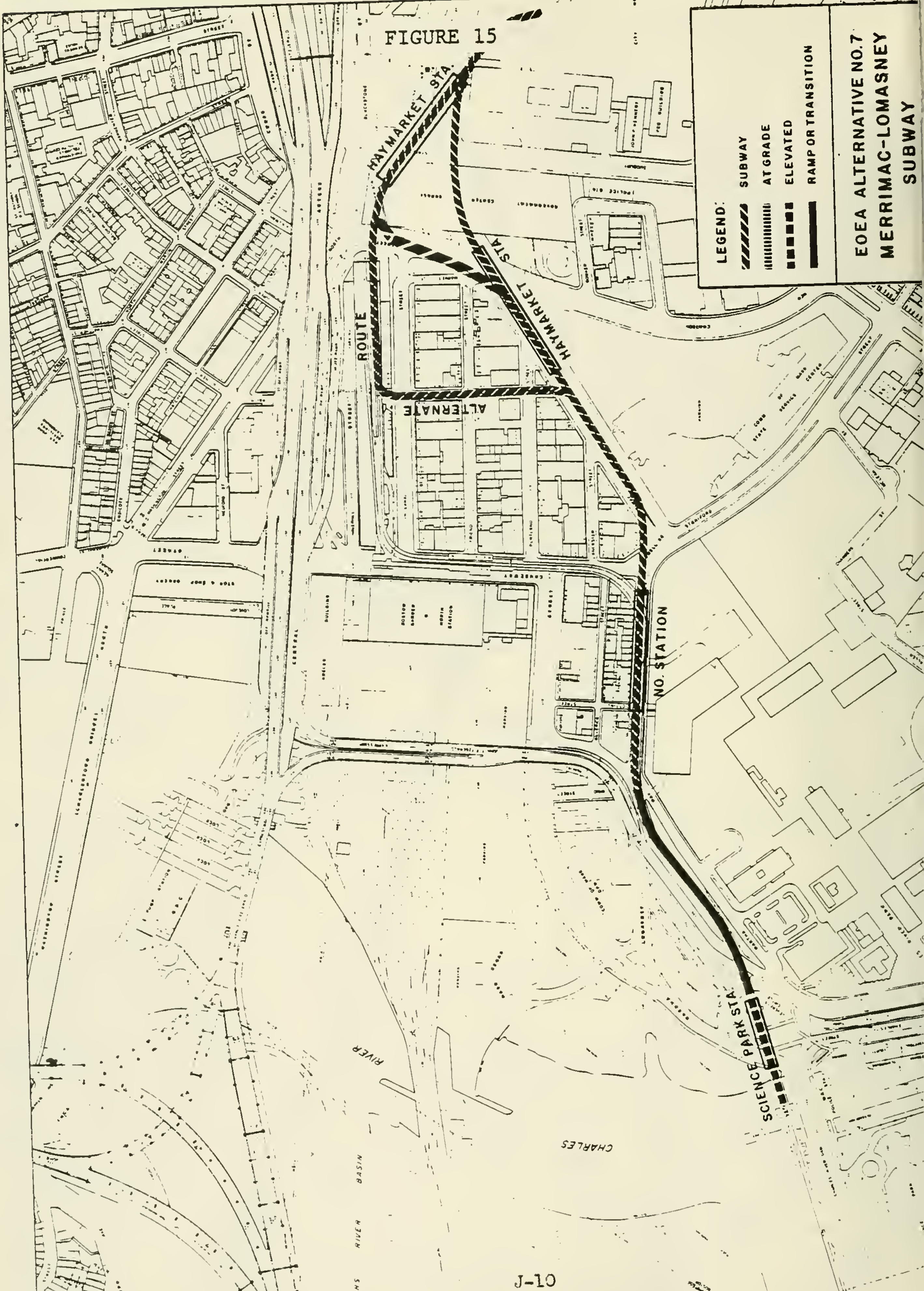

LEGEND:
▨ SUBWAY
AT GRADE
ELEVATED
RAMP OR TRANSITION
EOEA ALTERNATIVE NO.6
SUBWAY TO
CAMBRIDGE
AUGUST, 1980
HAYMARKET STA.
NO. STATION
CHARLES
RIVER
BASIN
0
200
400
600

FIGURE 15



EOEA ALTERNATIVE NO.7
MERRIMAC-LOMASNEY
SUBWAY

4.3 Basic Premises and Design Determinants

The evaluation of the several alternatives, described above, was governed by certain basic premises and design determinants, as well as by specific areas of environmental concern. In this analysis, there were two basic premises or assumptions:

1. The Green Line relocation is a rebuilding of an existing service and, as such, should not involve consideration of a change in service, i.e., the termination of Light Rail service at North Station and replacement of service beyond by buses.

2. The Green Line service is an important element in the transportation service available to Boston, Cambridge and other areas in the northwest sector of the Boston region. As such, service must be maintained throughout the North Station development and construction period, without any major service interruptions.

In attempting to ascertain what kinds of Green Line relocation alternatives are realistically possible, it is first necessary to identify those factors which should be taken into account when considering any alternative. It is apparent that some very important controlling determinants exist; these are summarized as follows:

1. Charles River Crossing

Although it is possible to envision a new Charles River crossing (either tunnel or bridge), the practicality of such new crossing must be judged in the context of abandoning the existing Charles River Dam viaduct and Science Park Station. For several reasons, including the fact that the viaduct is on the National Register of Historic Places (making its elimination extremely difficult), that the viaduct can be maintained structurally and its elimination would represent a resource waste, and the fact that the Massachusetts Legislature has mandated service to Science Park Station (Chapter 359, Acts of 1954), it is considered highly unlikely that the viaduct and station can be eliminated as a link in the system. This would mean that the relocation options considered would all have to link to the existing station and viaduct.

2. Haymarket Station

Since the existing Haymarket Station has been considerably remodelled, fits within tight tolerances with respect to the Government Center parking garage and utility lines, and performs its functions satisfactorily, any Green Line relocation alternatives should meet the existing Haymarket Station without substantial station modification.

3. Transition Requirements - Subway to Elevated

The length of any transition from below ground to elevated viaduct depends on the respective depth and height of the tracks being joined and the allowable intervening slope. The MBTA has a maximum design standard of 5% for track slopes. Since the elevation of the track at Science Park is about 30 feet above surrounding grade, the vertical transition from a subway section would be approximately 50 feet. Therefore, the length of a transition would be considerable and embrace a minimum horizontal distance of 800 feet.

Moreover, the transition from a tunnel portal below to a viaduct above represents a considerable barrier, which, for most of its length, cannot be crossed by either pedestrians or vehicles without an auxilary structure or tunnel. Thus the spatial design requirements of a transition are very crucial to a Green Line relocation, and the needs of existing and future land uses will severely limit its location.

4. Construction under the Existing Elevated

The basic problem of depressing the Green Line in its present alignment would be to construct the new facility while keeping the existing service 40 feet, or so above. While this might be technologically possible by means of extensive underpinning and other construction methods, the extra costs involved and the extended construction time necessary are judged to be excessive and should be avoided. However, this concept may well have to be accepted for limited sections, in order to connect the new alignment to the existing.

5. Considerations of New Elevated Sections

Although one of the major objectives of the North Station Urban Renewal Plan is the removal of the elevated section of the Green Line on Causeway Street, utilization of an elevated section, if properly designed, should not be summarily rejected. It is felt that the negative aspects of an elevated structure are closely associated with its nature and arrangment with respect to adjacent land uses. However, an elevated structure can be enclosed and integrated along or within adjacent development, so that its presence could be in relative harmony with its immediate environs (as an example, see Figure 31). Also, over the last few decades, both structural and acoustical engineering have advanced technologically such that both appearance and noise can be dealt with in new and better ways, apart from any architectural integration noted above. Thus it appears that there are enough opportunities and design approaches such that an elevated section deserves consideration as a relocation possibility.

6. At-Grade Operations

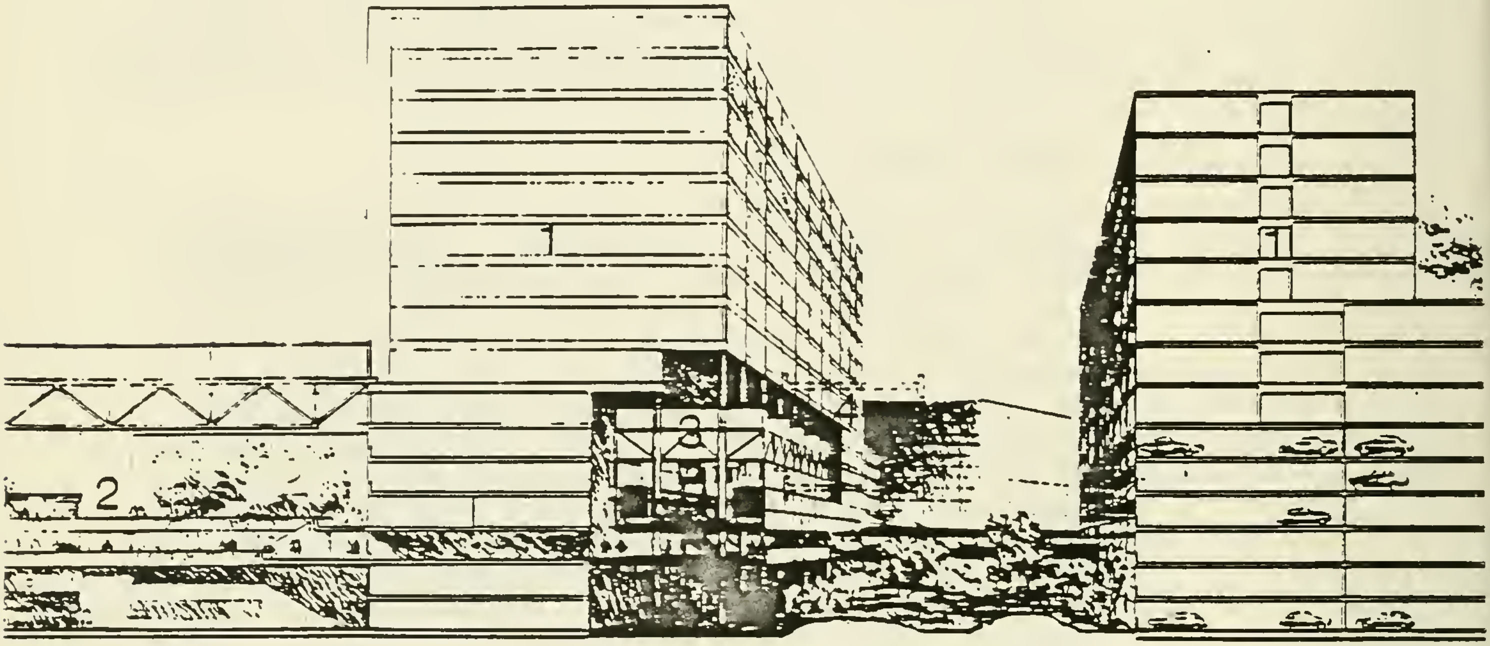
An at-grade operation, without dedicated, uninterrupted passage as now exists on the viaduct, would degrade the level of service - travel time, headways, reliability -at a key patronage area in the line. In addition, the street rights-of-way available have sections which are restrained in width such that there is not enough space for proper Green Line reservation and maintenance of vehicular traffic even if at-grade service were otherwise considered appropriate. Morever, the congesting effect on general traffic would have potentially adverse environmental consequences, such as increased air pollution, and the increase in the number of conflicts could also increase accident potential for both vehicles and persons. Therefore, any at-grade operations which must interrupt or be interrupted by the movements of general traffic and pedestrians is considered unacceptable.

7. New Station Needs

The present Haymarket and Science Park Stations are approximately 3,700 feet apart, a distance considered too short to allow more than one station (1,500 feet is considered a minimum distance between stations). Consequently, the range of station spacing for a new North Station stop is rather limited. Morever, looking at existing and proposed major transit patronage generation, the new station should, if possible, provide immedate access to North Station commuter rail patrons, Boston Garden, and the proposed new Federal Office Building, as well as give good access to the Phase II development area. Particularly important is the conveniences of a new North Station Green Line stop to the commuter rail operations.

4.4 Environmental Considerations

In the context of the North Station setting, there are a number of specific environmental concerns to which the Green Line options must relate, in addition to those implied by the design determinants. These include:



1 Proposed North Station Area Development

2 Concourse for relocated Commuter Rail platforms

3 Proposed North Station Green Line Station

4 Existing I-93/Storrow Drive Connector Ramps

Figure 31

Conceptual View showing intergration of relocated elevated Green Line into B.R.A. North Station Area Development Plan (looking southwest)

1. Noise - An adverse impact today, proposed alternatives must be evaluated according to noise producing potential. Unacceptable noise will depend chiefly upon the existence, locations, and design of any viaduct, transition, or at-grade sections of track and the location and severity of curves.

2. Air Quality - Any alternative which would tend to create more congested conditions for general traffic than presently exist would increase air pollution levels, violating the State Implementation Plan.

3. Aesthetics and Physical Disruption - A viaduct, transition section, or at-grade operation could be unsightly, present a barrier, and block air and light from adjacent land uses. Careful location and design are necessary to prevent or mitigate this. An improperly designed station could also be obtrusive.

4. Construction - The nature, complexity, and duration of construction activities are of concern and could vary widely according to the alternative chosen. Alternatives which involve at-grade and above-grade construction activities could have more significant disruptive effects during construction than might the below-grade options. All options which remove the existing elevated structure along Causeway Street and Lomasney Way would adversely affect both general traffic and pedestrian circulation. Maintaining transit operations and general traffic flow during construction will require special construction staging considerations.

5. Cost - Construction costs are of concern not only from a funding aspect, but also with regard to cost effectiveness. High costs must also carry with them great environmental gain. Operational cost is probably similar among all the alternatives. Construction costs, however, cannot be the sole basis for rejection of a particular alternative. (It should be noted that the construction costs estimates given below in the alternative evaluation discussion are extremely preliminary at this time).

6. Historic Preservation - The Massachusetts State Historic Preservation Officer has expressed the opinion that the Bulfinch Triangle area (bounded by Causeway Street, Haverhill Street, and Merrimac Street) would meet the eligibility requirements for inclusion in the National Register of Historic Places and that the existing Green Line elevated structure also may be eligible. Only the no-build option would not adversely affect either of these

properties. The impact of the alternatives through the Bulfinch Triangle area would depend on their design and the possibility of requiring property acquisition.

Due the nature of the North Station project area itself, being a completely urbanized environment on mostly filled land not now subject to flooding, there are a number of other environmental categories which none of the Green Line alternatives would affect in a significant manner. These categories include: (a) water quality, (b) wetlands, (c) ecologically sensitive areas, (d) flooding, (e) navigable waterways and coastal zones, (f) parklands, and (g) endangered species. In addition, because of the commmon grade differences and similar distances of all of the alternatives, the energy requirements would be similar for all options from the point-of-view of operations. Energy required for construction, however, would be another matter.

In the areas of land acquisition, displacement, land use, and zoning, the Urban Renewal Plan represents the chief determining factor. It would appear that none of the alternatives would have differing requirements in this regard, though the No-Build alternative clearly violates the land use planning for the area.

4.5 Evaluation of Alternatives

Each alterantive is examined below with respect to its feasibility in relation to the design determinants described above and with respect to its potential environmental impact. This discussion is followed by summary matrices listing the relationship of the alternatives against the basic premises, design determinants, and environmental factors.

1. No Build

This no action base condition represents an untenable position if the North Station Urban Renewal Plan is to proceed, since the existing elevated on Causeway Street has been judged as too blighting an influence on redevelopment prospects and should be eliminated. Apart from this, it fits most of the design determinants but does not have ideal pedestrian links to North Station and the Boston Garden and suffers from a degree of obsolence or old age.

Environmentally, this alternative produces an adverse noise environment, causes poor air quality from the entrapment of vehicle-generated carbon monoxide, has adverse aesthetic qualities and impedes efficient traffic circulation.

2. At-Grade Relocation

The relocation of the Green Line with any part of the alignment at-grade introduces, as discussed earlier, a degradaton of operations due to the interference caused by direct conflicts with general traffic and pedestrians.

Considering the situation in the North Station area, there appears to be no opportunity or special circumstances which would allow a significant at-grade section without substantial cross interference.

If the existing transition from subway to surface level were utilized, an at-grade section would have to run along Causeway Street, run behind North Station, or run through the Bulfinch Triangle on Traverse Street.

In the first case, interference would be severe along Causeway Street and at the intersection of Causeway and Lomasney Way. In the second case, interference would exist in the area of Causeway Street and Accolon Way and at the level of the commuter rail tracks, foreclosing the opportunity to extend the tracks to the North Station concourse as well as crossing pedestrian paths.

In the third option, Traverse Street does not have sufficient width for both transit and vehicle rights-of-way. This option also could adversely affect the historic qualities of the Bulfinch Triangle area.

An at-grade option would represent an investment in creating degraded Green Line operations and related additional pedestrian and traffic conflicts, resulting in increased traffic congestion which would cause more air pollution. It therefore is not considered acceptable.

3. Relocation of Elevated behind North Station via Accolon Way

If a new viaduct is designed using the best knowledge of acoustical and structural engineering and is properly integrated into the architectural framework and functional character of the new development, this alternate is quite compatible with the design determinants discussed.

This alternative can be achieved by careful design (acoustics structure, appearance, enclosure) and alignment such that noise and physical and visual intrusion are minimized. As discussed previously, such a harmionous design is possible by integration of the structure and station platforms with (joint) development, properly located with respect to building uses. Additionally, the effects of a relocated elevated structure would be further reduced by the existance of the Storrow Drive Connector ramps.

A relocated elevated structure as envisioned affords the opportunity to build the North Station stop above the commuter rail platforms. This is perhaps the most desirable location for transfers from commuter rail and service to the Boston Garden, as well as being convenient to the proposed GSA building and Phase II urban renewal development. A mezzanine Green Line station between the transit line and commuter rail tracks would be at a similar level to the pedestrian connection envisioned between Phases I and II of the renewal plan.

Generally, there do not appear to be any major construction problems involved with a relocated elevated except for a conflict with two existing service links over Accolon Way between the Annelex Building and the Boston Garden, which contain service pipes and are necessary for the delivery of large items to the Garden and, on occassion, for elephant crossings. Replacement or rearrangement of building uses would be an essential part of the elevated option.

4. Subway along Existing Alignment

The construction of a subway beneath the existing viaduct, while maintaining service, presents extreme problems of underpinning and structural security. While this may be technically possible, it is also very costly and time-consuming and should only be considered as a last resort or for some uniquely paramount reasons. Failing these, this alternative is judged not feasible. From the environmental standpoint, however, a subway would have no adverse impact on air quality, and noise and physical disruption would be confined to the transition section.

5. Subway below Boston Garden

This option does not violate the design determinants in any significant fashion and can be considered feasible. However, the construction costs would be extremely high as extensive underpinning to support the existing wood piles under Boston Garden would be necessary. This work could be avoided by making a straighter alignment that would put the subway under the Madison Hotel, but such a routing is considered unacceptable since it would conflict with the proposed Federal Office Building. Other environmental impacts would be similar to those described for Alternative #4, with the Madison Hotel option additionally having a potential adverse effect on the Bulfinch Triangle.

6. Subway below Boston Garden and the Charles River to Cambridge

This alternative discards the existing acceptable Charles River Dam viaduct, eliminates Science Park Station, and requires a new tunnel crossing of the Charles River. A major determinant (maintenance of the Science Park Station and Charles River Dam viaduct) is therefore violated and this scheme is assessed as not being feasible. In addition, the construction of a new tunnel under the Charles River could result in potential conflicts with DPW plans for relocating the northbound Storrow Drive/Central Artery Connector in a tunnel segment from Leverett Circle to the Artery in Charlestown.

This alternative also would be extremely costly (in excess of $150 million) and would involve a lengthly construction period, inconsistent with the current replacement schedule. On the other hand, the option would have favorable environmental consequences with respect to noise, air quality, aesthetics and physical disruption.

7. Merrimac Street/Lomasney Way Subway

This subway alternative is reasonably consistent with most established determinants and appears to be feasible. However, the station location for the North Station stop would have to be on Lomasney Way adjacent to the GSA site. This is considered quite inconvenient due to its distance from the commuter rail terminal and Boston Garden and thus incompatible with this design determinant.

In addition, in order to retain the existing Haymarket Station (which is considered necessary), a very sharp radius carve near the northern edge of the Government Center parking garage would be necessary. This would present problems of detailed routing with respect to streets and existing properties and the construction at the junction with existing service. A moderately curved alignment from the Haymarket area would imply the elimination of the existing Haymarket Station and the construction of a new station on Merrimac Street closer to North Station. This violates one of the design determinants, interrupts Green to Orange Line transfers at Haymarket, and locates the station somewhat less conveniently to the surrounding development.

Environmentally, this alternative would have no adverse affect on air quality, and noise and physical disruption/barrier impacts would be limited to the transition section.

8. Replacement with Bus Service

This course of action would discard the existing Green Line dedicated light rail line, introduce lower capacity bus operations, violate the urban renewal plans of Cambridge in the Lechmere area and redevelopment plans in Somerville, and forwgo the possibility of more one-seat rides into the central subway system which a Green Line (Northwest) extension would otherwise afford. Moreover, this option would have adverse noise impacts, and the potential increase in traffic congestion plus additional buses could generate higher air pollution levels.

Conclusions

On the basis of the various assessment items and design deterimants, there appear to be but two general options which can be considered to be feasible and acceptable for further consideration. These involve either a tunnel from Haymarket Station to a transition linking to the elevated Science Park Station (Alternatives #5 and #7) or a new relocated elevated behind North Station (Alternatives #3), the latter being very contingent on good design and location. For the subway options, construction difficulties and station location represent the major problems. Both of these alternatives "themes" will be the subject of more detailed evaluation in an Environmental Impact Report to be prepared by the MBTA.

TABLE 39

NORTH STATION GREEN LINE RELOCATION OPTIONS -
RELATIONSHIP TO BASIC PREMISES AND DESIGN DETERMINANTS

	Basic Premises				Design Determinants				
Alternative	No Mode Change	Service During Constr.	No New Charles Crossing	Retain Haymarket	Trans-tion Problems	Construc-tion Under Existing	New Elevated Compati-bility	At-Grade Operations	Station Locations
1. No-Build									
2. At-Grade Section		x			x			x	
3. Relocated Elevated							*		
4. Subway under Existing		x				x			
5. Subway under N. Station									
6. Subway to Lechmere			x						x
7. Merrimac/Lomasney Subway		x		*	x	x			x
8. Bus Substitution	x							x	

Key:

x = irreconcilable violation of basic premise or design determinant

* = depends on location and design chosen

TABLE 40
NORTH STATION GREEN LINE RELOCATION OPTIONS RELATIONSHIP TO ENVIRONMENTAL FACTORS

Alternative	Noise	Air Quality	Aesthetics - Physical Description	Construction Problems	Cost ($ Millions)	Historic Properties*
1. No-Build	Adverse	Entraps CO; dirt from viaduct	Adverse	None	None	Preserves elevated structure
2. At-Grade Section	Moderate; possibly high at sharp curves	Increased pollution from more traffic congestion	Relatively adverse	Potential problems building under elevated and transition	$10-$20	Possibly adverse with Traverse St. option
3 Relocated Elevated	Acceptable if design & location are right	No adverse effect	Depends on design	Least interference with existing service	$30-$50	No adverse effect
4 Subway under Existing	Confined to transition section	No adverse effect	Good except at transition	Difficulties with underpinning existing elevated and transition	$45-$70	No adverse effect
5. Subway under N Station	Confined to transition section	No adverse effect	Good except at transition	Major problems tunnelling under/near Boston Garden	$60-$90	Possibly adverse with Madison Hotel option
6. Subway to Lechmere	No adverse effect	No adverse effect	Good - no distruption	Problems tunnelling under Boston Garden and river; lengthy period	$150+	No adverse effect
7. Merrimac/Tomasney Subway	Confined to transition section	No adverse effect	Good except at transition	Possibly difficult at Haymarket to Merrimac and transition	$45-$75	Possibly adverse with Traverse St. option
8 Bus Substitution	Adverse	Increased pollution from buses, traffic congestions	Fair	Simple bus terminal	±$6	No adverse effect

* All options (except No-Build) assume demolition of the Green Line elevated, possibly eligible for National Register listing. Evaluation confined to Bulfinch Triangle area.

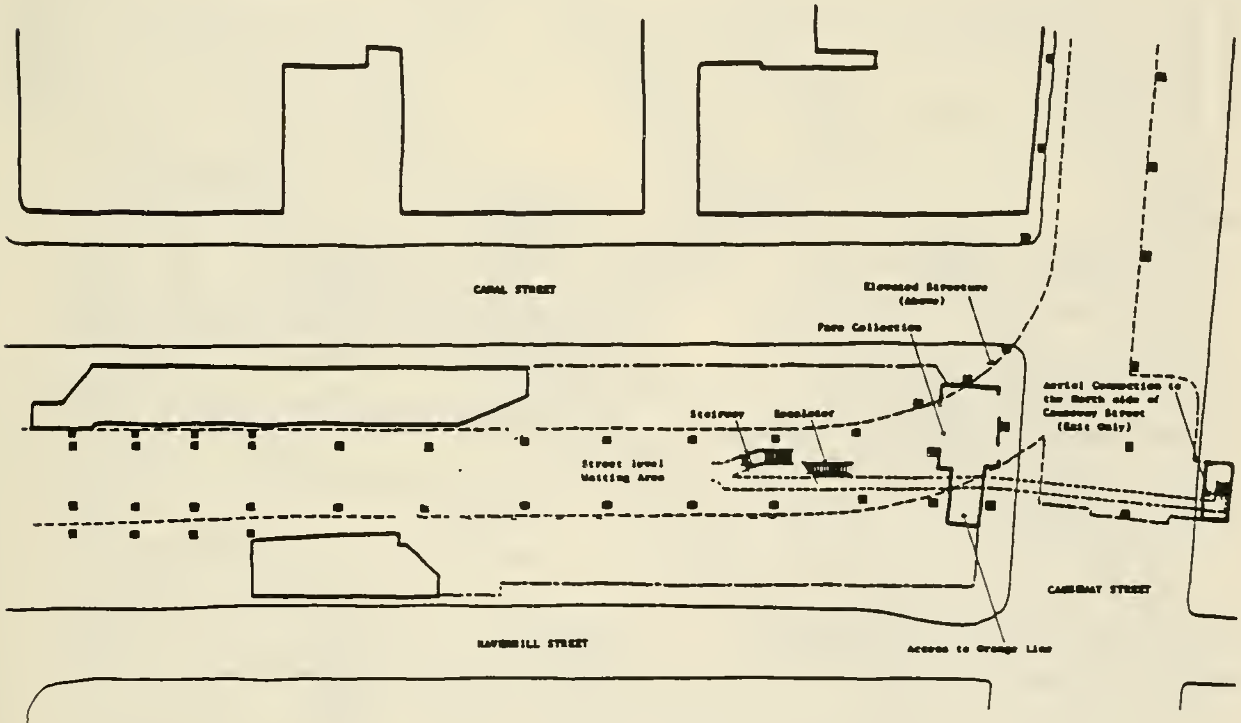
Appendix K GREEN LINE RELOCATION ALTERNATIVES - ADVANTAGES AND DISADVANTAGES

Green Line Alternative 1A Refurbished Base Case

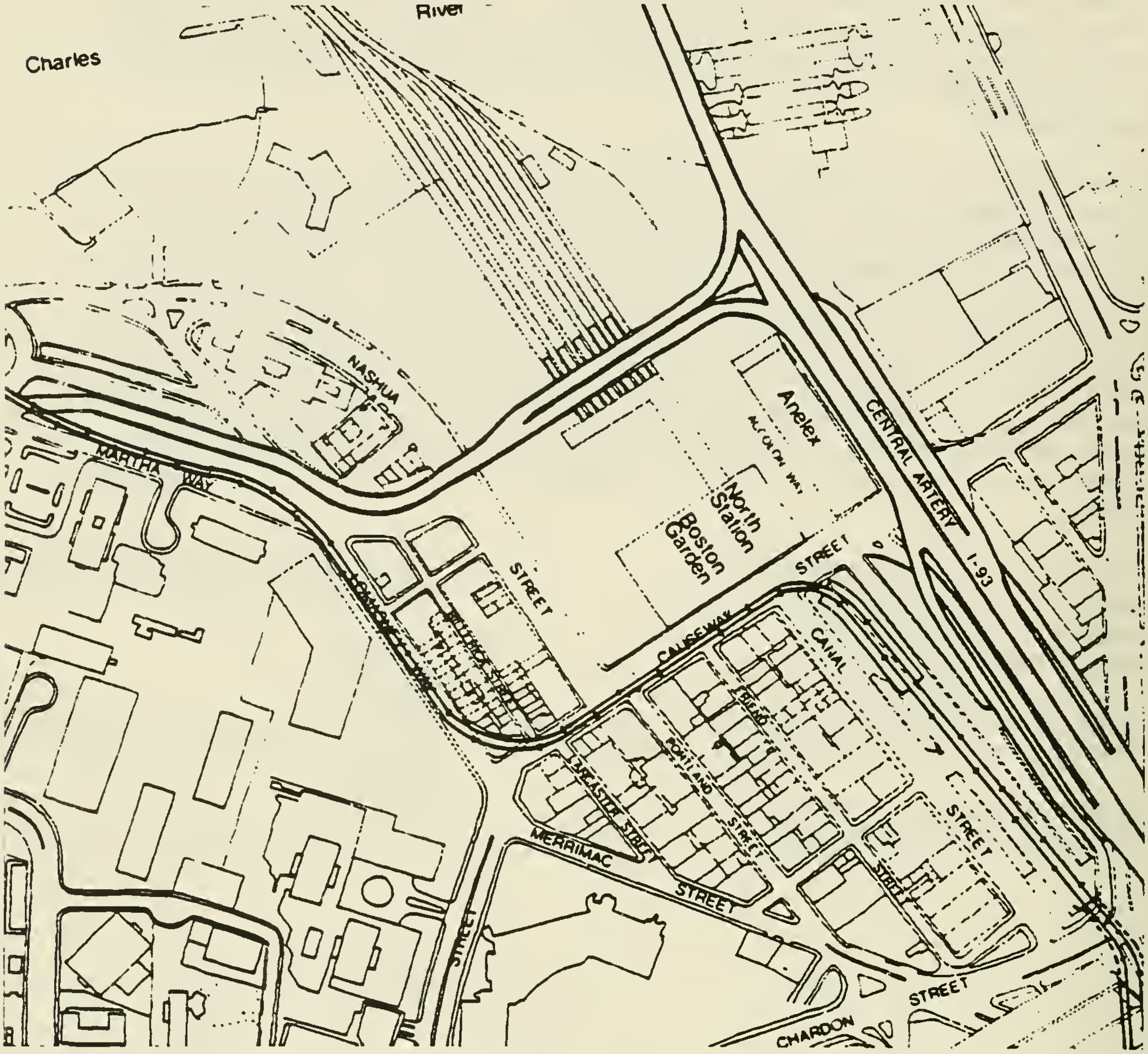
Alternative 1A provides for improvements to the existing North Station Green Line facilities, while essentially retaining the existing alignment. Three types of treatments are proposed: station modernization/operations improvements, structural improvements, and noise reduction improvements.

Alternative 1A includes a new station with a center-loaded island platform located above the MBTA's existing Canal Street facilities; removal of abandoned platforms and excess non-load bearing structure above Causeway Street; and noise reduction measures such as continuous welded rail, new noise-dampening resilient rail fasteners, ballast mats (or floating slabs) and acoustical treatment under the elevated structure. A minimum of four structure bents will have to be replaced, to accommodate the BRA's proposed roadway improvements at Lomasney Way and Causeway Street. According to the BRA, this roadway improvement has long been considered as an essential component of improving traffic flow through the area and is required regardless of future BRA redevelopment plans.

Green Line Station Location	Above Canal Street facilities
Length of Elevated Section	Remains the same
Length of Subway Section	0'
Construction Difficulty	Minimum
Utility Difficulty	Minimum
Possible Takings/Easements	None
Maintenance of Service During Construction	No - 6 to 12 month disruption in service
Joint Development Potential	None
Preliminary Cost Estimate	$56 million (construction costs)


CANAL STREET
Elevated Structure (Above)
Fare Collection
Stairway
Escalator
Street level Waiting Area
Aerial Connection to the North side of Causeway Street (Exit Only)
CAUSEWAY STREET
HAVERHILL STREET
Access to Orange Line

STREET LEVEL PLAN



Advantages

1) least expensive "build" alternative
2) station would have one fare collection facility
3) minimal disruption to businesses
4) Canal Street turnback can be maintained

Disadvantages

1) transition grade increased
2) maintenance of existing elevated alignment continues adverse impact on development in North Station area
3) station would not service proposed development north of the existing Boston Garden
4) major disruption in service during construction
5) tight radius curves will still exist

Cost: $56 million (construction costs)

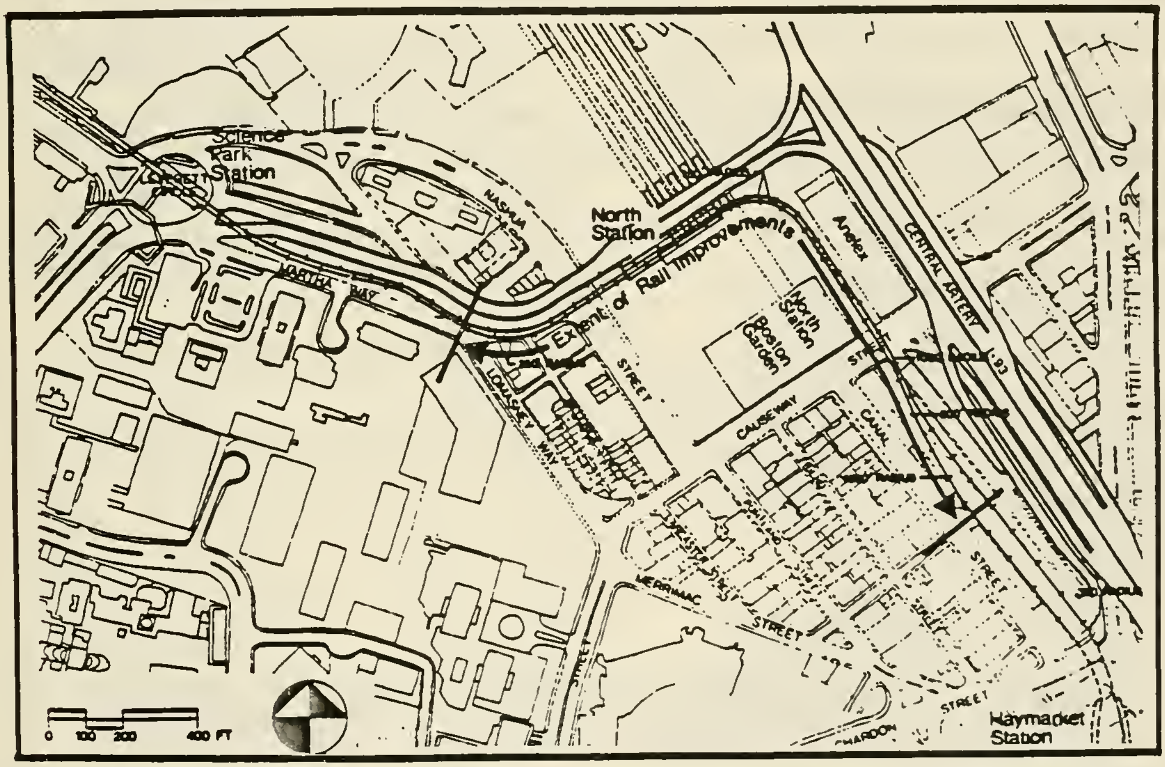
Comment: Alternative 1A does not meet the goals of the North Station developments.

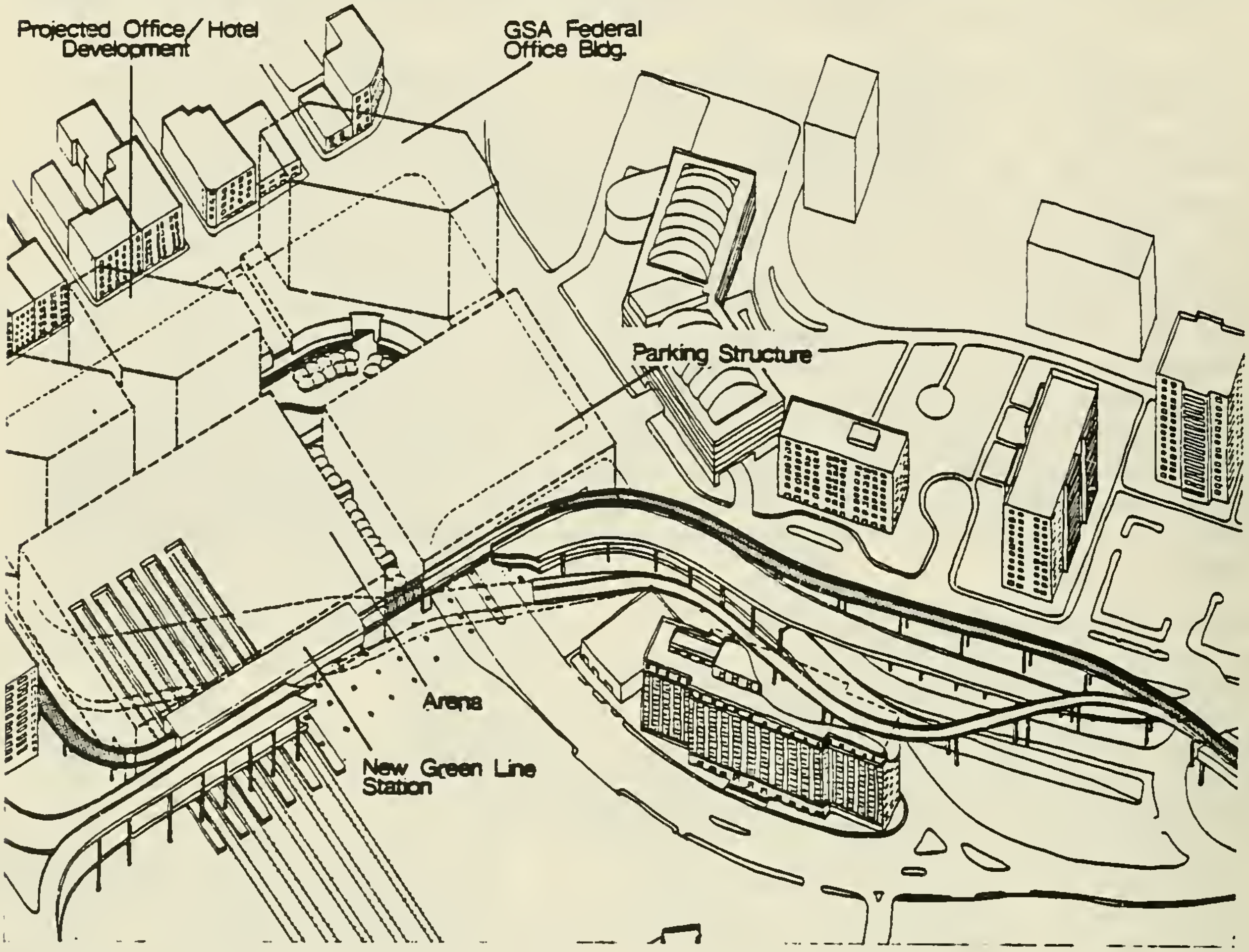
Green Line Alternative 3 Relocated Elevated Structure

(Based on analysis contained in the EIS which is almost complete; the MBTA anticipates seeking funding for construction of this alternative.)

Alternative 3 provides for a new elevated structure to be constructed east and north of the Boston Garden and above the MBTA commuter rail platforms. In this alternative, the Green Line tracks emerge from the subway portal near Haymarket Station and rise to an elevated alignment adjacent to the existing subway-to-elevated transition zone. The alignment then crosses Causeway Street and continues northerly between the Boston Garden and the Anelex Building to the existing Central Artery elevated ramps. The new elevated Green Line then parallels the south-side of the highway structure to Lomasney Way without further vertical transition. The new elevated structure joins the existing elevated structure at Lomasney Way. The station associated with this alternative is located to the north of the Boston Garden above the commuter rail tracks and adjacent to the connector ramps. At this location, the station is on the border between the BRA's proposed Phase I and Phase II development areas and affords excellent access to the development sites and commuter rail.

Green Line Station Location	Behind Boston Garden
Length of Elevated Section	3200'
Length of Subway Section	0'
Construction Difficulty	Minimum
Utility Difficulty	Minimum
Possible Takings/Easements	Minimum
Maintenance of Service During Construction	Yes
Joint Development Potential	Very good - can be integrated with parking structure, new Boston Garden or office building
Preliminary Cost Estimate	$104 million (construction costs)





Advantages

1) least expensive relocation alternative

2) good station location to service arena, GSA, commuter rail and proposed developments

3) alignment within public right-of-way

4) alignment at the periphery of Phase I development

5) transition from subway to elevated in present location

6) Canal Street turnback can be maintained

7) minimal disruption of Green Line during construction

8) profile of the elevated is similar to Central Artery ramps

9) minimal disruption to businesses

Disadvantages

1) new elevated must join existing elevated structure at Lomasney Way and Martha Way

2) more noise than subway options

3) must be integrated into proposed development

4) existing elevated connections between the Boston Garden and the Analex Building must be removed

5) utility connections between the Boston Garden and the Analex Building must be relocated

6) existing elevated structure opposite Charles River Park will remain

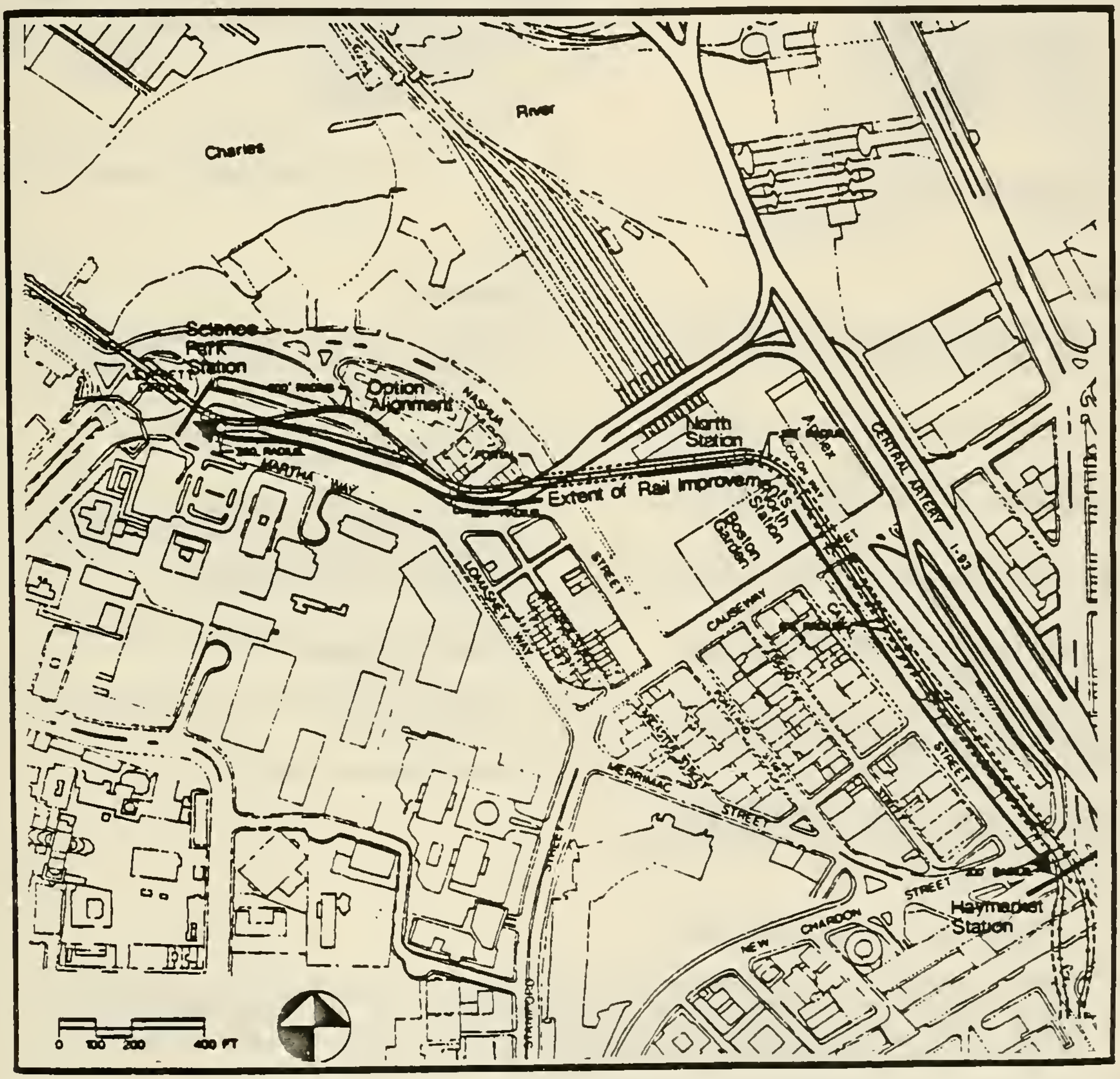
Costs: $104 million (construction costs)

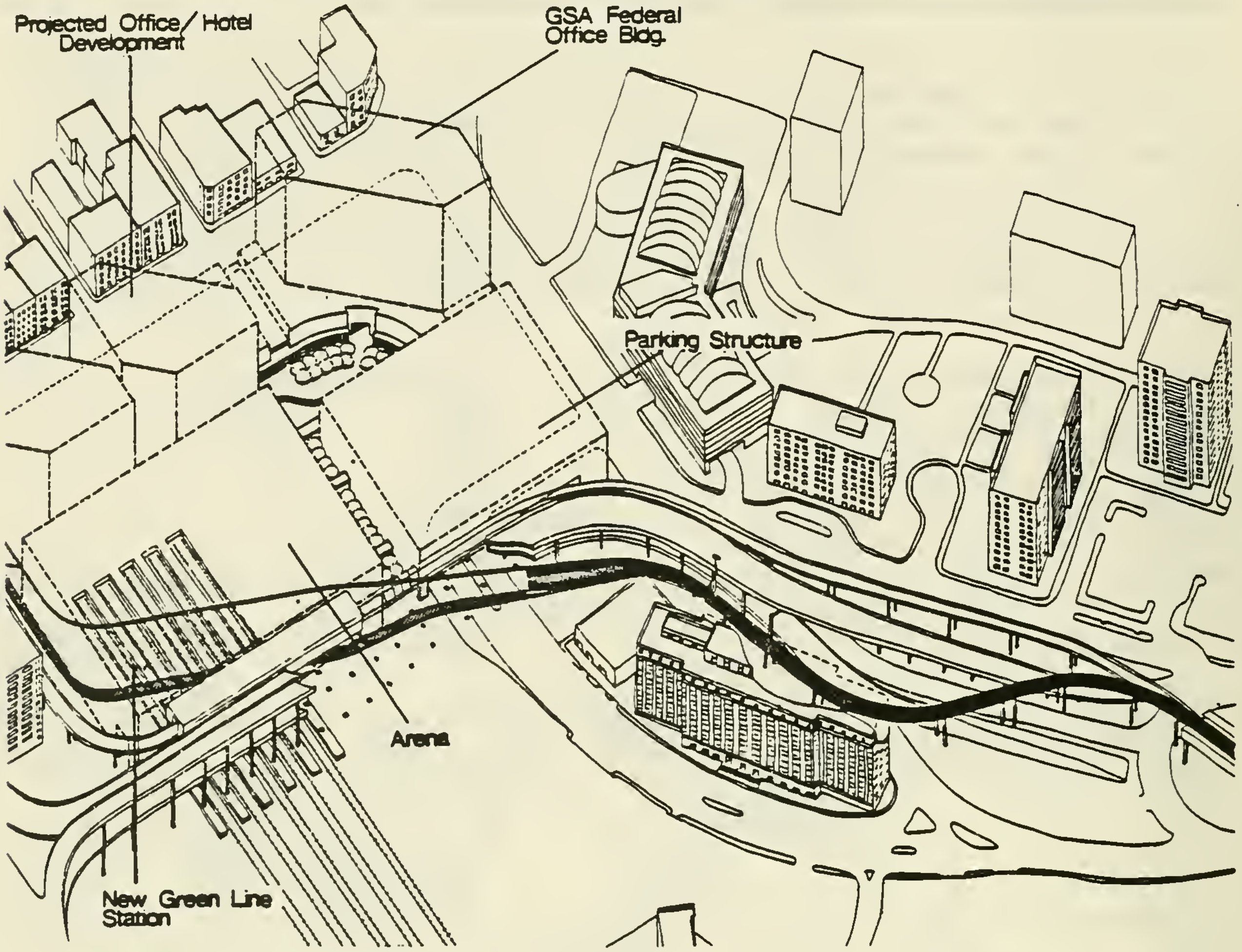
Comment: Alternative 3 meets all the planning goals of the proposed North Station developments and will cause the least disruption of service and have the minimum construction impact. Alternative 3 is the least expensive to construct and will be carried into further design study.

Green Line Alternative 5C Partial Subway

This alternative provides for a below-grade alignment extending northerly from Haymarket Station, adjacent to the Haymarket North Extension (Orange Line) Tunnel and beneath the easterly end of the Boston Garden, to the Central Artery connector ramps. After passing under the ramps in a subway configuration, the alignment makes full vertical transition from subway to elevated profile, passes over Lomasney Way and joins the existing elevated Green Line structure at Science Park Station. The new Green Line station is located behind the Boston Garden under the proposed commuter rail platform extension area.

Green Line Station Location	Behind Boston Garden
Length of Elevated Section	1200'
Length of Subway Section	2000'
Construction Difficulty	Major
Utility Difficulty	Moderate
Possible Takings/Easements	Moderate
Maintenance of Service during Construction	Yes - Requires temporary structure
Joint Development Potential	Excellent
Preliminary Cost Estimate	$185 million (construction costs)





Advantages

1) The alignment remains in a subway profile until it passes beneath the Central Artery ramps.

2) Business disruption would be minimal.

3) Good station location to service arena, GSA, commuter rail and proposed developments.

4) Transition occurs north of Central Artery ramps.

5) The alignment does not inhibit planned street improvements.

6) The alignment does not affect existing elevated connections at the Analex Building and Boston Garden.

7) A knockout panel could be included in the design to accommodate a future below-grade crossing to Cambridge.

Disadvantages

1) Subway construction will require costly foundation restructuring and underpinning at the Boston Garden.

2) Costly structural modifications to the Central Artery ramps.

3) The transition zone may require the relocation of a portion of the Boston Edison steam-generating facility which is considered for future development.

4) Steep profile in transition area exceeds desirable gradient.

5) The existing MDPW motor pool facility would be dislocated.

6) Costly temporary Canal Street ramp.

Costs: $185 million (construction costs)

Comment: Alternative 5C has an unobstrusive subway alignment, a centralized station location, and unique to this alignment, fewer tight-radius turns than the other subway alternatives. This alternative meets the objectives of the proposed developments and will be carried into further design and incorporated into the DEIS.

Appendix L WATER CONSUMPTION/SEWERAGE GENERATION DATA

1. Basis for Water Consumption/Sewerage Generation Estimates
2. Estimates for Daily Water Consumption and Sewerage Generation
3. Boston Water and Sewer Commission Letter

Appendix L-1

BASIS FOR WATER CONSUMPTION/SEWERAGE GENERATION ESTIMATES

Demand Category	Consumption/Generation Rate (Daily)*
Residential (@ 1.75 persons/unit)	125 gal./capita (1)
Office (@ 1 employee/200 s.f. GLA)	55 gal./employee (2)
Retail/Commercial	0.1 gal./s.f. GLA (3)
Public/Museum	0.1 gal./s.f. (4)
Hotel	200 gal./room (5)
Hospital	200 gal./bed (6)
Boston Garden (@ full capacity)	3 gal./spectator (6)
	25 gal./participant-employee (6)
Parkland (irrigation)	60 gal./1000 s.f. (5)
Transients/Visitors	5 gal./capita (2)

Sources:

(1) Boston Redevelopment Authority Engineering Department estimates.

(2) Camp Dresser & McKee, Report on Improvements to the Boston Main Drainage System, Vol. I (HUD Project No. P-Mass-3306), Boston, September 1967, p. V-27.

(3) HMM Associates, Inc., Copley Place Final Environmental Impact Report/ Environmental Impact Statement, Waltham, September 22, 1980, P. 7-101.

(4) Boston Redevelopment Authority estimate.

(5) U.S. Department of Housing and Urban Development, San Francisco Office, Final Environmental Impact Statement - Yerba Buena Center Redevelopment Area, California R-59, in San Francisco, California, San Francisco, October 1974, Appendix D, Table F-2.

(6) Department of Environmental Quality Engineering, State Environmental Code, Title V, Section 15.02 (310 CMR 15.00 et. seq.).

* Sewage generation is estimated to be equal to 90% of daily water demand.

Appendix L-2

ESTIMATES OF DAILY WATER CONSUMPTION AND SEWERAGE GENERATION

1. Water Consumption

	Preferred Program (gallons)	Optional Program (gallons)
Phase I Development Area*		
Retail/Commercial	12,500	12,500
Office	264,000	264,000
Parking	17,325	17,325
Boston Garden (@ full occupancy)	53,250	53,250
Transients/Visitors	34,150	34,150
	381,225	381,225
Phase II Development Area		
Retail/Commercial	9,000	2,500
Office	-	121,275
Hotel	80,000	-
Residential	240,625	65,625
Public/Museum	11,500	-
Hospital	-	56,800
Parking	25,410	17,325
Parkland (irregation)	16,800	24,300
Transients/Visitors	73,600	73,650
	456,935	361,475
Total Project Area		
Maximum average daily demand (with Garden event)	838,160	742,700
Maximum daily demand		
(@ 150% of average)	1,257,240	1,114,050
(@ 200% of average)	1,676,320	1,485,400
Peak daily demand (@ 300% of average)	2,514,480	2,228,100

Source: Appendix L-1.

* Development of a hotel, rather than a private office building, on the North Station site would reduce daily water consumption demand by 31,750 gallons.

2. Sewerage Generation

Sewerage generation is estimated to be equal to 90% of daily water demand:

Preferred Program

Sub-area I	343,105 gal.
Sub-area II	411,240 gal.
	754,345 gal.

Reduced-Scale Program

Sub-area I	343,105 gal.
Sub-area II	325,325 gal.
	668,430 gal.

(Development of a hotel, rather than a private office building, on the North Station site (Sub-area I) would reduce daily sewerage generation by 28,575 gallons.)

Source: Camp Dresser & McKee, Report on Improvements to the Boston Main Drainage System, Vol. I (HUD Project No. P-Mass-3306), Boston, September 1967, p. V-18. Generation based on analysis of MDC and City water records and other data furnished by the City, which showed that 80% of the water supplied to the City was discharged into the sanitary sewer system, with 10% of intake leakage prior to consumption.

Boston Water and Sewer Commission

10 Post Office Square
Boston, Massachusetts 02109
617-426-6046

December 22, 1981

Mr. Richard B. Mertens
Environmental Review Officer
Boston Redevelopment Authority
One City Hall Square
Boston, MA 02201

Re: North Station Project Utilities
BWSC No. 81-3S

Dear Mr. Mertens:

We have received your letter dated December 11, regarding your requirements for information concerning our existing water and sewer facilities servicing the areas of both Phase I and Phase II of the North Station Project.

The existing main trunk lines for sewerage and drainage include the 60-inch X 90-inch brick overflow in Nashua Street; a 32-inch X 54-inch brick combined sewer on Causeway Street and Lomasney Way, as well as 40-inch X 48-inch reinforced concrete combined sewer underneath the expressway. These lines are at the upper end of a collection system and the current flows are very low. We feel that these lines are more than adequate to service your proposed facilities.

The existing water low service lines in the area are supplied by a 30-inch line on Causeway Street, laid in 1970. The high service is limited to a 12-inch main on Causeway Street which is supplied from a 16-inch feeder system from downtown Boston.

Recent flow information taken from the low service system in the area shows an adequate water supply for your proposed facilities. However, there is no recent flow information on the high service system. Our present plans call for cleaning and cement lining of the major service mains in the area in the near future.

If you have need of additional information or any questions, please feel free to contact us.

Very truly yours,

Thomas E. Monahan, P. E.
Division Engineer

TEM/SS/mg

Appendix M SOLID WASTE GENERATION DATA

1. Basis for Solid Waste Generation Estimates
2. Estimates of Daily Waste Generation
3. Estimates of Construction-Related Debris

Appendix M-1

BASIS FOR SOLID WASTE GENERATION ESTIMATES

Generation Category	Generation Rate (Daily)
Residential (@ 1.75 persons/unit)	3.3 lbs/capita (1)
Office (@ 1 employee/200 of GLA)	2.2 lbs/employee (1)
Retail/Commercial	4 lb/100 s.f. (2)
Hotel (@ 1.5 guests/room, 70% occupancy)	2.4 lbs/capita (3)
Public/Museum	1 lb/100 s.f. (3)
Hospital	20 lbs/bed (4)
Boston Garden (@ full capacity)	1 lb/100 s.f. (3)
Parking facilities	0.2 lbs/100 s.f. (3)
Public open space	0.4 lbs/100 s.f. (3)
Transients/Visitors	0.2 lbs/capita (5)
Street refuse	0.11 lbs/capita (1)

Sources:

(1) National averages

(2) HMM Associates, Inc., Draft Environmental Impact Report for Devonshire Towers, prepared for Devonshire Associates, Inc., May 1979, Appendix F.

(3) U.S. Department of Housing and Urban Development, San Francisco Office, Final Environmental Impact Statement - Yerba Buena Center Redevelopment Area, California R-59, in San Francisco, California, San Francisco, October 1974, Appendix D, Table D-3.

(4) Solid waste generation data from Peter Bent Brigham Hospital and Affiliated Hospital Center, Boston; National Sanitation Foundation, Disposal of Single Use Items from Health Care Facilities, 1970.

(5) Boston Redevelopment Authority estimate.

Appendix M-2

ESTIMATES OF DAILY SOLID WASTE GENERATION

	Preferred Program (lbs.)	Optional Program (lbs.)
Phase I Development Area*		
Retail/Commercial	5,000	5,000
Office	10,560	10,560
Parking	1,050	1,050
Open Space	160	160
Boston Garden (@ full occupancy)	4,850	4,850
Transients/Visitors	1,365	1,365
Street Refuse	3,140	3,140
	26,125 (13.06 tons)	26,125 (13.06 tons)
Phase II Development Area		
Retail/Commercial	3,600	1,000
Office	-	4,850
Hotel	1,010	-
Residential	6,355	1,735
Public/Museum	1,150	-
Hospital	-	5,680
Public Park Area	960	1,460
Parking	1,540	1,050
Transients/Visitors	3,595	3,595
Street Refuse	2,305	2,400
	20,515 (10.26 tons)	21,770 (10.89 tons)
Total Project Area		
Average Daily	46,640 lbs. (23.32 tons)	47,895 lbs. (23.95 tons)
Annual	8,512 tons	8,742 tons

Source: Appendix M-1.

* Development of a hotel, rather than a private office building, on the North Station site would reduce daily soild waste generation by 3370 lbs (1.69 tons) and annual generation by 613 tons.

Appendix M-3

ESTIMATES OF CONSTRUCTION-RELATED DEBRIS

1. DEMOLITION DEBRIS

Building demolition debris estimated to equal 30% of building volume (BRA Engineering Department estimate).

Preferred Program

Sub-area I	(36 buildings):	132,920 cu. yds. debris
Sub-area II	(7 buildings):	49,070 cu. yds. debris
		181,990 cu. yds. debris

Reduced-Scale Program

Sub-area I	(36 buildings):	132,920 cu. yds. debris
Sub-area II	(5 buildings):	4,225 cu. yds. debris
		137,145 cu. yds. debris

2. Excavation Material

(a) Building Sites

Excavation required for new building construction is subject to existing site conditions and the presence of existing basement levels. For Sub-area I development, excavation is very grossly estimated to equal 50,000-100,000 cu. yds., and for Sub-area II, approximately 65,000 cu. yds. (35,000 cu. yds. for the reduced-scale program).

(b) Canal

Preferred Program: 211,000 sq. ft. x 20 ft. depth = 4,220,000 cu. ft.
= 156,296 cu. yds.
Reduced-Scale Program: 175,000 sq. ft. x 20 ft. depth = 3,500,000 cu. ft.
129,630 cu. yds.

(c) Green Line (Subway Option)

Tunnel Sections	528,000 cu. ft.
Station/platform area	990,000 cu. ft.
	1,518,000 cu. ft.
	(56,222 cu. yds.)

(BRA estimate)

(d) Storrow Drive Connector Relocation (Tunnel Option)

Tunnel sections (within North Station Project Area)	5,361,600 cu. ft. (198,578 cu. yds.)

(BRA estimate)

3. Construction Debris

Construction debris estimated to equal 70 cu. yds. per 20,000 sq. ft. building area (Chatterjee, S., Urban, L.V., and Mickucki W., "Planning Suffers from Lack of Building and Demolition Debris Data," Solid Wastes Management, February, 1975, p.12)

Preferred Program

Sub-area I (2,200,000 sq. ft., new construction): 7,700 cu. yds. debris
Sub-area II (2,500,000 sq. ft., new construction): 8,750 cu. yds. debris
16,450 cu. yds. debris

Reduced-Scale Program

Sub-area I (2,200,000 sq. ft., new construction): 7,700 cu. yds. debris
Sub-area II (1,390,000 sq. ft., new construction): 4,865 cu. yds. debris
12,565 cu. yds. debris

Appendix N ANALYSIS METHODS AND INPUT DATA FOR AIR QUALITY ANALYSIS

APPENDIX A: ANALYSIS METHODS AND INPUT DATA*

The air quality impact analysis of the North Station Urban Renewal Project consisted of the estimation of carbon monoxide (CO), oxides of nitrogen (NO_x), and nonmethane hydrocarbons (NMHC) from all motor vehicles in a traffic-impacted areas, and the diesel locomotives. From these emissions, an estimation was made of the maximum 1-hr and 8-hr CO concentrations from motor vehicle sources for baseline conditions (1980) and the various project alternatives for the years 1987 and 2000. This technical appendix does not contain the results of the air quality impact analysis; rather, it details the modeling procedures and the input data that were used to arrive at the impact results.

1. Estimating Emissions from Motor Vehicle Sources

Emissions from motor vehicle sources were estimated by using factors as compiled in EPA's MOBILE 2 program [5]. These emission factors were made more specific to the analysis of North Station by applying a number of correction factors to the input data, as described in the following sections.

Vehicle Registration Data

Vehicle registration data for the light-duty vehicle class (comprising all of the private passenger automobiles) showing distribution of the vehicle population by age, as used by the EPA procedures, were replaced by registration data that pertained to Massachusetts. These data were provided by the Massachusetts Department of Environmental Quality Engineering (DEQE) and are shown in Table A-1 along with national registration data for the other vehicle classes. The Massachusetts data show that the automobile population is generally "older" compared with the national average (about 45% of the automobiles in Massachusetts are five years old or less vs 50% for the national average).

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* From: Bolt Beranek and Newman, Inc., Report No. 4477

TABLE A-1. THE FRACTION OF TOTAL VEHICLE REGISTRATION FOR DIFFERENT VEHICLE CATAGORIES DISTRIBUTED BY AGE OF VEHICLES.

Age of Vehicles (years)	Light-Duty Vehicles	Light-Duty Trucks <6000 lb	Light-Duty Trucks 6000–8500 lb	Heavy-Duty Gasoline	Heavy-Duty Diesel	Motorcycle
1	0.072	0.061	0.037	0.037	0.077	0.105
2	0.089	0.095	0.070	0.070	0.135	0.225
3	0.078	0.094	0.078	0.078	0.134	0.206
4	0.102	0.103	0.086	0.086	0.131	0.149
5	0.113	0.083	0.075	0.075	0.099	0.097
6	0.104	0.076	0.075	0.075	0.090	0.062
7	0.089	0.076	0.075	0.075	0.082	0.046
8	0.086	0.063	0.068	0.068	0.062	0.033
9	0.072	0.054	0.059	0.059	0.045	0.029
10	0.063	0.043	0.053	0.053	0.033	0.023
11	0.043	0.036	0.044	0.044	0.025	0.008
12	0.034	0.024	0.032	0.032	0.015	0.005
13	0.023	0.030	0.038	0.038	0.013	0.013
14	0.013	0.028	0.036	0.036	0.011	0.000
15	0.007	0.026	0.034	0.034	0.010	0.000
16	0.004	0.024	0.032	0.032	0.008	0.000
17	0.002	0.022	0.030	0.030	0.007	0.000
18	0.002	0.020	0.028	0.028	0.006	0.000
19	0.002	0.018	0.026	0.024	0.004	0.000
20	0.001	0.016	0.024	0.024	0.004	0.000

Distribution of Vehicle-Miles-Traveled (VMT) According to Vehicle Category

The national distribution of the VMT that is used to develop a composite emission factor consists of 80.3% automobiles, 11.6% light-duty trucks, 4.5% heavy-duty gasoline trucks, 3.1% heavy-duty diesel trucks, and 0.5% motorcycles. This distribution was used on all major arterials except the expressway and the parking facilities. For the expressway, the assumed VMT mix is 80.7% automobiles, 14% light-duty trucks, 4.8% heavy-duty trucks, and 0.5% motorcycles. For the parking facilities, the vehicle population is assumed to be 100% automobiles.

Mix of Cold, Stabilized, and Hot Transient Operations

Automobile exhaust emission rates are influenced by the temperature of the engine. A vehicle operated in the cold phase, for example, will have higher emission rates of CO than if the same vehicle were operated in a stabilized phase. For the 24-hr analysis, the percent of vehicle-miles-traveled (VMT) accumulated in the noncatalyst cold start, the catalyst hot start, and the catalyst cold start modes are, respectively, 21%, 27%, and 21%. For the 8-hr analysis, the noncatalyst cold start is about 28%, the catalyst hot start, 27%, and the catalyst cold start, 49%. For the 1-hr analysis, the percentage of cold start was increased so that the corresponding percent noncatalyst cold start, catalyst hot start, and catalyst cold start, are, respectively, 37%, 27%, and 55%.

Ambient Temperature

Emission rates of CO decrease with increasing ambient temperatures. The Federal Test Procedure (FTP) data were taken over a range of temperatures from 68°F to 86°F. There is a basis in the model for adjusting to the temperatures that are applicable in the specific situation. Where appropriate to the modeling analysis in estimating CO emissions at North Station, an ambient temperature of 30° F was used. For estimating NO_x and NMHC emissions, an ambient temperature of 75°F was assumed.

Traffic Volume Data

Traffic volumes are a direct measure of activity and are used along with the emission factors to obtain emission rates. Traffic volume data were provided by the Boston Redevelopment Authority [6] in a number of formats depending on end use. The formats include free flow traffic on local streets and the expressway, intersections, and parking garages and lots.

Figure A-1 shows the local road network used in the modeling analysis. Tables A-2 and A-3 show the 1-hr, 8-hr, and 24-hr traffic volumes for the local roads for baseline (1980) conditions and for the various project alternatives. Figure A-2 is a schematic of the expressway, and Tables A-4 and A-5 shows the 1-hr, 8-hr, and 24-hr traffic volumes that were used for the modeling analysis of the portion of the expressway and ramps that are in the project area. Traffic data used in the modeling analysis assumed that the peak 1-hr traffic occurred between 5:00 p.m. and 6:00 p.m. Modeling of 8-hr concentrations were based on actual projections of traffic volumes between 10:00 a.m. and 6:00 p.m.

Traffic volumes for Preferred and Optional Alternatives are based on implementation of Scheme I in 1987; implementation of Scheme II in 1987 would result in slightly lower volumes in 2000.

In addition to the free flow analysis, detailed analyses of nine intersections in the project area were made for all alternatives. Tables A-6 through A-15 show the 1-hr demand and average 8-hr volumes, approach capacities, signal cycle times, green phase times, and number of lanes per approach for all intersections analyzed for all alternatives.

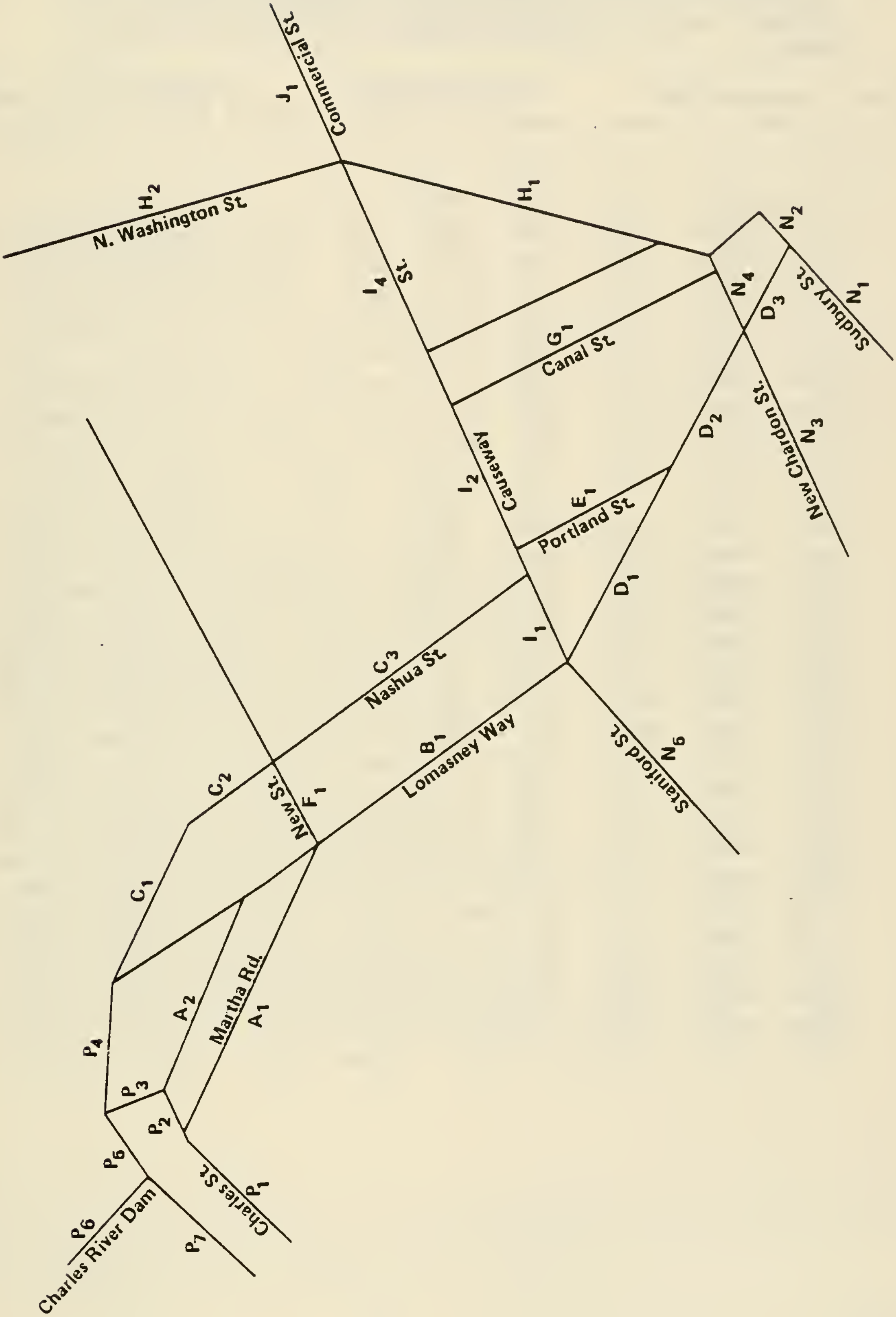

FIG. A.1. LOCAL ROADS NETWORK AS USED IN THE NORTH STATION MODELING ANALYSIS.

TABLE A-2. ESTIMATED PEAK HOUR, 8-HOUR AND 24-HOUR TRAFFIC VOLUMES FOR 1980 BASELINE AND VARIOUS PROJECT ALTERNATIVES IN 1987 ON LOCAL STREETS IN THE NORTH STATION AREA.

Road Link	Baseline 1980			1987 No Build			1987 Scheme I			1987 Scheme II		
ID *	pk-hr	8-hr	24-hr	pk-hr	8-hr	24-hr	pk-hr	8-hr	24-hr	pk-hr	8-hr	24-
A_1	280	4617	6603	290	4778	6834	474	6636	9940	474	6636	994
A_2	91	1774	2815	93	1883	2887	1242	9286	16884	1176	9135	1660
B_1	202	4053	6041	288	4209	6076	1945	18174	29151	1879	17689	2901
C_1	1129	10180	17941	1250	10520	18539	948	6762	11708	895	6660	1157
C_2	1129	10180	17941	1250	10520	18539	948	6762	11708	895	6660	1157
C_3	1555	11806	20364	1384	12149	20969	0	0	0	0	0	
D_1	546	4371	5712	561	4491	5869	1123	7389	11325	1060	6850	1018
D_2	568	4547	5942	584	4675	6110	1088	7159	10972	1052	6798	976
D_3	1402	9748	15386	1447	10058	15887	1605	10119	16050	1564	9798	1587
E_1	435	2109	4162	449	2176	4296	67	325	641	67	325	64
F_1	0	0	0	0	0	0	840	1788	3485	706	1673	341
G_1	257	2276	5563	266	2355	5757	202	1788	4372	202	1788	437
H_1	1539	9453	16459	1590	9769	17010	1590	9769	17010	1590	9769	1701
H_2	2490	12900	30640	2640	13483	31617	2793	18106	32480	2257	18084	3243
I_1	716	5660	12762	760	5881	13262	1475	11414	25739	1475	11414	2573
I_2	1452	11480	25880	1531	11847	26716	1531	11847	26716	1531	11847	2671
I_4	1395	12692	24676	1499	13046	25349	1765	13859	26909	1706	13735	2667
J_1	1298	8933	19083	1337	9200	19656	1432	9519	20312	1409	9382	1997
N_1	1102	7871	15910	1141	8146	16467	1141	8146	16647	1141	8146	1646
N_2	1268	9057	18307	1312	9367	18935	1360	9710	19842	1348	8717	1945
N_3	940	6805	12491	973	7043	12928	997	7145	13119	991	7112	1305
N_4	937	6783	12451	970	6952	12764	970	6952	12764	970	6952	1276
N_5	1036	8291	12515	1179	8539	12874	1273	8883	13405	1251	8869	1338
P_1	2850	19182	45190	2920	19585	46139	3012	19848	46760	3012	19716	4470
P_2	3660	24634	58033	3851	25040	58991	3922	25845	60887	3910	25594	5803
P_3	535	3601	8483	554	3602	8486	1339	8824	20781	1277	8359	1613
P_4	1527	13768	24266	1586	13902	24295	1307	9323	16142	1197	9284	1617
P_5	2108	19007	33499	2140	19296	34008	2847	20307	35161	2604	19418	3382
P_6	2238	15537	39480	2274	16036	40757	2498	16266	41417	2468	16245	41358
P_7	1080	7101	16105	1104	7313	16580	1316	7600	17207	1266	7563	1715

* See Fig. A-1 for location of road links.

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TABLE A-3. ESTIMATED PEAK HOUR, 8-HOUR, AND 24-HOUR TRAFFIC VOLUMES FOR VARIOUS PROJECT ALTERNATIVES IN 2000 ON LOCAL STREETS IN THE NORTH STATION AREA.

Road Link	2000 No-Build			2000 Preferred†			2000 Optional†		
ID*	pk-hr	8-hr	24-hr	pk-hr	8-hr	24-hr	pk-hr	8-hr	24-hr
A_1	397	4811	6880	735	8401	12575	663	6842	9875
A_2	97	1955	2997	1157	10146	18518	996	10059	18361
B_1	300	4386	6331	2410	21836	35050	2156	21679	34807
C_1	1320	11112	19570	0	0	0	0	0	0
C_2	1320	11112	19570	0	0	0	0	0	0
C_3	1460	12817	22120	0	0	0	0	0	0
D_1	593	4747	6204	1523	7680	11587	1385	7643	11521
D_2	618	4947	6466	1391	7014	10583	1246	6876	10365
D_3	1525	10612	16739	1919	10431	17036	1785	10353	16865
E_1	466	2259	4459	72	348	687	69	334	660
F_1	0	0	0	1630	3106	6339	1233	2161	4410
G_1	282	2503	6099	214	1899	4628	214	1899	4628
H_1	1685	10340	18005	1685	10340	18005	1685	10340	18005
H_2	2794	14271	33466	3196	18868	34920	3062	14458	34426
I_1	816	6130	14226	1688	12185	28278	1688	12185	28278
I_2	1622	12185	28278	1688	12185	28278	1688	12185	28278
I_4	1584	13776	26752	2234	16354	29100	2032	16270	28950
J_1	1411	10011	20985	1658	9414	22425	1604	8849	21607
N_1	1191	8504	17192	1191	8504	17192	1191	8504	17192
N_2	1384	9882	19978	1484	10596	17183	1460	10425	16846
N_3	1033	7487	13742	1083	7547	13852	1071	7543	13847
N_4	1031	7473	13715	1055	7352	13494	1040	7254	13435
N_5	1261	9118	13650	1559	10965	14921	1424	9521	14219
P_1	3126	20329	47892	3238	20756	48894	3155	20749	48882
P_2	4022	26156	61619	4409	28262	66576	4303	27958	66569
P_3	575	3739	8809	1732	17492	31930	1571	15866	28961
P_4	1672	14075	24789	0	0	0	0	0	0
P_5	2247	20260	35708	3327	33600	61334	3059	30894	56392
P_6	2399	16920	43036	2986	17275	45048	2784	17246	44968
P_7	1146	7564	17190	1590	7946	18719	1482	7919	18651

*See Fig. A-1 for location of road links.

†Based on Scheme I development for 1987.

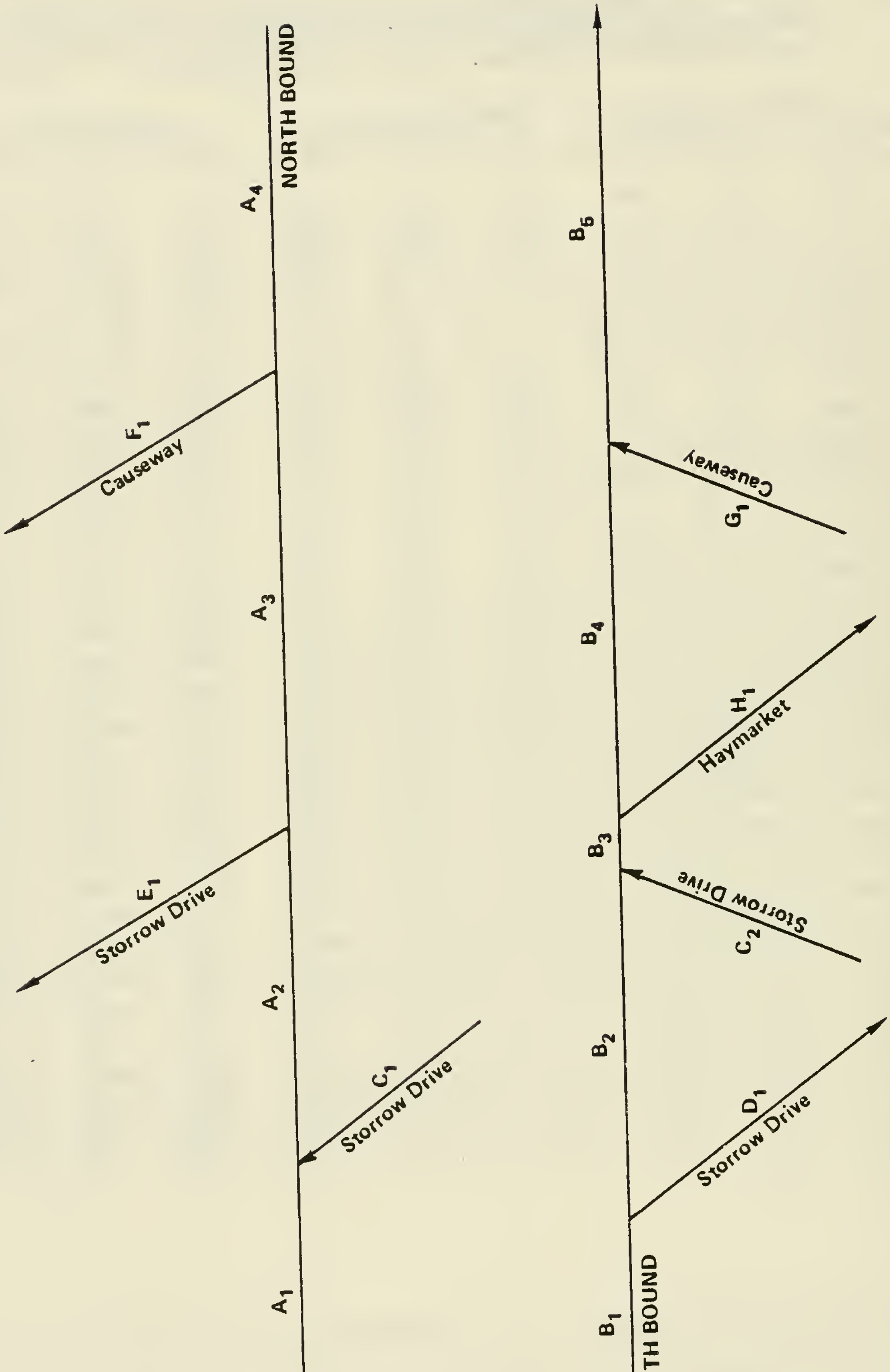

FIG. A.2. SCHEMATIC OF EXPRESSWAY AND RAMPS USED IN THE NORTH STATION MODELING ANALYSIS.

TABLE A-4. ESTIMATED PEAK HOUR, 8-HOUR, AND 24-HOUR TRAFFIC VOLUMES FOR 1980 BASELINE AND VARIOUS PROJECT ALTERNATIVES IN 1987 ON EXPRESSWAY AND RAMPS IN THE NORTH STATION AREA.

Road Link	Baseline 1980			1987 No-Build			1987 Schemes I & II		
ID*	pk-hr	8-hr	24-hr	pk-hr	8-hr	24-hr	pk-hr	8-hr	24-hr
A_1	5360	34441	69300	5469	36078	70924	5487	36317	71760
A_2	3260	22911	46100	3264	23971	46564	3264	23971	46564
A_3	4400	35634	71700	4461	37330	73444	4461	37330	73444
A_4	4690	39719	81800	4762	41542	83585	4762	41542	83585
B_1	3750	34242	68900	3968	35796	72345	3968	35796	72345
B_2	2430	23458	47200	2582	24631	49560	2582	24631	49560
B_3	3140	34293	69000	3328	36007	72450	3328	36007	72450
B_4	2810	31957	64300	2981	33554	67515	2981	33554	67515
B_5	3280	36076	72707	3467	37817	76216	3628	38730	76924
C_1	2100	11530	23200	2205	12107	24360	2223	12346	25196
C_2	710	10835	21800	746	11376	22890	746	11376	22890
D_1	1320	10784	21700	1386	11165	22785	1386	11165	22785
E_1	1140	12723	25600	1197	13359	26880	1197	13359	26880
F_1	290	4085	10100	301	4212	10141	301	4212	10141
G_1	470	4119	8407	486	4263	8701	608	4337	8852
H_1	330	2336	4700	347	2453	4935	347	2453	4935

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* See Fig. A-2 for identification of road links.

TABLE A-5. ESTIMATED PEAK HOUR, 8-HOUR, AND 24-HOUR TRAFFIC VOLUMES FOR VARIOUS PROJECT ALTERNATIVES IN 2000 ON EXPRESSWAY AND RAMPS IN THE NORTH STATION AREA.

Road Link	2000 No-Builds			2000 Preferred†			2000 Optional†		
ID*	pk-hr	8-hr	24-hr	pk-hr	8-hr	24-hr	pk-hr	8-hr	24-hr
A_1	5796	38632	75959	5944	38111	76800	5921	38085	76244
A_2	3437	25678	49894	3497	25173	49894	3437	25173	49894
A_3	4718	39973	78656	4718	39973	78656	4718	39973	78656
A_4	5038	43823	89436	5119	45349	89589	5059	45020	89522
B_1	4800	43637	87802	4800	43637	87802	4800	43637	87802
B_2	3317	31520	63422	3317	31520	63422	3317	31520	63422
B_3	4115	43693	87914	4115	44190	87914	4115	44190	87914
B_4	3744	41069	82634	3744	41069	82634	3744	41069	82634
B_5	4245	45445	91587	4435	45819	92327	4385	45790	92269
C_1	2359	12954	26065	2447	12938	26406	2424	12912	26350
C_2	798	12173	24492	798	12173	24492	798	12173	24492
D_1	1483	12117	24380	1483	12117	24380	1483	12117	24380
E_1	1281	14295	28762	1281	14295	28762	1281	14295	28762
F_1	320	4477	10780	401	5376	10942	341	5047	10866
G_1	587	4386	8953	691	4750	9693	641	4721	9635
H_1	371	2624	5280	371	2624	5280	371	2624	5280

* See Fig. A-2 for identification of road links.

† Based on Scheme I development for 1987.

TABLE A-6. TRAFFIC INPUT DATA FOR THE PARKING ANALYSIS OF THE PROPOSED PARKING AREAS.

	GSA*	I-2*	I-3*	II-6A†	II-6B**	II-7A†	II-7B***
Demand Volumes (VPH) ††							
1-hr	105	394	197	269	279	284	93
8-hr	23	142	71	72	91	63	17
Entrance Capacities (cars/min)	12	12	12	12	12	12	12
Exit Capacities (cars/min)	6	6	6	6	6	6	6
Capacity of Lot (spaces)	267	1000	500	1100	1400	1100	100
Total Running Time (seconds)							
1-hr	100	522	381	537	624	521	70
8-hr	88	324	185	341	429	483	61

* Garage implemented in Phase I, but demand volumes and capacities and other garage parameters remain unchanged in Phase II.

† Garage implemented in Phase II for the Preferred Alternative

** Garage implemented in Phase II for the Optional Alternative

†† Demand volumes equal the average of the entrance and exit volumes

*** Parking lot implemented in Phase II for the Optional Alternative

TABLE A-7. TRAFFIC INPUT DATA FOR THE INTERSECTION AT LEVERETT CIRCLE OF THE CHARLES RIVER DAM AND NASHUA STREET FOR ALL ANALYSIS YEARS AND ALTERNATIVES.

General		
Approach	Charles River Dam	Nashua Street
Signal Length (sec)	100	100
Number of Lanes	2	2
1980 Baseline		
Demand Volume (VPH) pk-hr/8-hr	596/684	882/1067
Green Phase Length (sec)	41	59
Capacity of Approach (VPH)	1081	1555
1987 No Build		
Demand Volume (VPH) pk-hr/8-hr	617/709	1126/1203
Green Phase Length (sec)	35	65
Capacity of Approach (VPH)	923	1713
1987 Scheme I		
Demand Volume (VPH) pk-hr/8-hr	617/709	1188/1059
Green Phase Length (sec)	34	66
Capacity of Approach (VPH)	896	1740
1987 Scheme II		
Demand Volume (VPH) pk-hr/8-hr	617/743	1126/1025
Green Phase Length (sec)	35	65
Capacity of Approach (VPH)	923	1713
2000 No Build		
Demand Volume (VPH) pk-hr/8-hr	659/757	1179/1260
Green Phase Length (sec)	36	64
Capacity of Approach (VPH)	949	1687
2000 Preferred		
Demand Volume (VPH) pk-hr/8-hr	778/807	1556/1706
Green Phase Length (sec)	33	67
Capacity of Approach (VPH)	870	1766
2000 Optional		
Demand Volume (VPH) pk-hr/8-hr	690/771	1402/1690
Green Phase Length (sec)	33	67
Capacity of Approach (VPH)	870	1766

TABLE A-8. TRAFFIC INPUT DATA FOR THE INTERSECTION AT LEVERETT CIRCLE OF CHARLES STREET AND MARTHA ROAD FOR ALL ANALYSIS YEARS AND ALTERNATIVES.

General		
Approach	Charles Street	Circle
Signal Length (sec)	100	100
Number of Lanes	5	3
1980 Baseline		
Demand Volume (VPH) pk-hr/8-hr	2850/2398	810/930
Green Phase Length (sec)	25	75
Capacity of Approach (VPH)	3107	906
1987 No Build		
Demand Volume (VPH) pk-hr/8-hr	2920/2448	838/963
Green Phase Length (sec)	75	24
Capacity of Approach (VPH)	3106	870
1987 Scheme I		
Demand Volume (VPH) pk-hr/8-hr	3012/2481	909/1044
Green Phase Length (sec)	74	26
Capacity of Approach (VPH)	3065	943
1987 Scheme II		
Demand Volume (VPH) pk-hr/8-hr	3012/2465	898/1031
Green Phase Length (sec)	75	25
Capacity of Approach (VPH)	3107	906
2000 No Build		
Demand Volume (VPH) pk-hr/8-hr	3126/2541	896/1029
Green Phase Length (sec)	75	25
Capacity of Approach (VPH)	3107	906
2000 Preferred		
Demand Volume (VPH) pk-hr/8-hr	3238/2595	1171/1214
Green Phase Length (sec)	71	29
Capacity of Approach (VPH)	2929	1051
2000 Optional		
Demand Volume (VPH) pk-hr/8-hr	3155/2594	971/1085
Green Phase Length (sec)	74	26
Capacity of Approach (VPH)	3065	943

TABLE A-9. TRAFFIC INPUT FOR THE INTERSECTION OF LOMASNEY WAY AND NEW STREET FOR ALL ANALYSIS YEARS AND BUILD ALTERNATIVES.

General			
Approach	New St.	Martha Rd.	Lomasney Way
Signal Length (sec)	100	100	100
Number of Lanes	4	3	2
1987 Scheme I			
Demand Volume (VPH) pk-hr/8-hr	840/224	474/829	961/1071
Green Phase Length (sec)	22	78	78
Capacity of Approach (VPH)	1063	2828	2056
1987 Scheme II			
Demand Volume (VPH) pk-hr/8-hr	706/209	474/829	961/1071
Green Phase Length (sec)	18	82	82
Capacity of Approach (VPH)	870	2973	2162
2000 Preferred			
Demand Volume (VPH) pk-hr/8-hr	1630/388	735/1050	1165/1156
Green Phase Length (sec)	37	63	63
Capacity of Approach (VPH)	1788	2284	1661
2000 Optional			
Demand Volume (VPH) pk-hr/8-hr	1233/270	663/855	1062/1151
Green Phase Length (sec)	34	66	66
Capacity of Approach (VPH)	1643	2393	1740

TABLE A-10. TRAFFIC INPUT DATA FOR THE INTERSECTION OF LOMASNEY WAY, MERRIMAC STREET, CAUSEWAY STREET, AND STANIFORD STREET FOR ALL ANALYSIS YEARS AND ALTERNATIVES.

General				
Approach	Lomasney Way	Merrimac St.	Causeway St.	Staniford St
Signal Length (sec)	100	—	100	100
1980 Baseline				
Number of Lanes	3	—	3	2
Demand Volume (VPH) pk-hr/8-hr	202/507	—	320/365	728/656
Green Phase Length (sec)	24	—	76	76
Capacity of Approach (VPH)	870	—	2755	2003
1987 No Build				
Number of Lanes	3	—	2	2
Demand Volume (VPH) pk-hr/8-hr	288/526	—	214/245	892/679
Green Phase Length (sec)	24	—	76	76
Capacity of Approach (VPH)	870	—	2003	2003
1987 Scheme I				
Number of Lanes	4	3	3	2
Demand Volume (VPH) pk-hr/8-hr	984/915	382/313	644/736	892/703
Green Phase Length (sec)	28	14	58	58
Capacity of Approach (VPH)	1353	508	2102	1529
1987 Scheme II				
Number of Lanes	2	3	3	2
Demand Volume (VPH) pk-hr/8-hr	479/595	382/231	644/736	892/703
Green Phase Length (sec)	25	15	60	60
Capacity of Approach (VPH)	659	544	2175	1582
2000 No Build				
Number of Lanes	3	—	2	2
Demand Volume (VPH) pk-hr/8-hr	300/548	—	228/251	957/729
Green Phase Length (sec)	24	—	76	76
Capacity of Approach (VPH)	870	—	2003	2003
2000 Preferred				
Number of Lanes	2	3	3	2
Demand Volume (VPH) pk-hr/8-hr	782/988	558/290	747/751	1007/772
Green Phase Length (sec)	31	16	53	53
Capacity of Approach (VPH)	817	580	1921	1397
2000 Optional				
Number of Lanes	2	3	3	2
Demand Volume (VPH) pk-hr/8-hr	685/976	492/287	747/751	970/768
Green Phase Length (sec)	30	16	54	54
Capacity of Approach (VPH)	791	580	1958	1423

TABLE A-11. TRAFFIC INPUT FOR THE INTERSECTION OF CAUSEWAY STREET AND THE EXPRESSWAY RAMP FOR ALL ANALYSIS YEARS AND ALTERNATIVES.

General				
Approach	C'way St. SB	C'way St. NB	X-way Rmp	Beverly St.
Signal Length (sec)	100	100	100	100
Number of Lanes	3	3	3	2
1980 Baseline				
Demand Volume (VPH) pk-hr/8-hr	614/808	650/568	290/509	60/61
Green Phase Length (sec)	61	61	39	39
Capacity of Approach (VPH)	2501	2501	1414	1028
1987 No Build				
Demand Volume (VPH) pk-hr/8-hr	616/648	999/839	301/527	63/63
Green Phase Length (sec)	54	54	27	19
Capacity of Approach (VPH)	1958	1958	979	501
1987 Scheme I				
Demand Volume (VPH) pk-hr/8-hr	616/853	999/839	301/527	466/467
Green Phase Length (sec)	62	62	12	26
Capacity of Approach (VPH)	2248	2248	435	685
1987 Scheme II				
Demand Volume (VPH) pk-hr/8-hr	616/849	999/839	301/527	320/321
Green Phase Length (sec)	68	68	13	19
Capacity of Approach (VPH)	2465	2465	471	501
2000 No Build				
Demand Volume (VPH) pk-hr/8-hr	661/870	1060/869	320/560	67/67
Green Phase Length (sec)	54	54	29	19
Capacity of Approach (VPH)	1958	1958	979	501
2000 Preferred				
Demand Volume (VPH) pk-hr/8-hr	792/1109	1060/869	401/565	897/898
Green Phase Length (sec)	53	53	15	32
Capacity of Approach (VPH)	1921	1921	544	844
2000 Optional				
Demand Volume (VPH) pk-hr/8-hr	718/1104	1060/869	320/631	699/700
Green Phase Length (sec)	61	61	10	29
Capacity of Approach (VPH)	2211	2211	363	764

TABLE A-12. TRAFFIC INPUT DATA FOR THE INTERSECTION AT KEANY SQUARE FOR ALL ANALYSIS YEARS AND ALTERNATIVES.

General				
Approach	C'town Bridge	N. Washington	Commercial	Causeway St.
Signal Length (sec)	100	100	100	100
Number of Lanes	3	3	2	3
1980 Baseline				
Demand Volume (VPH) pk-hr/8-hr	811/656	1124/704	295/279	781/779
Green Phase Length (sec)	23	33	12	22
Capacity of Approach (VPH)	750	1076	284	717
1987 No Build				
Demand Volume (VPH) pk-hr/8-hr	836/697	1161/727	314/297	872/806
Green Phase Length (sec)	25	35	13	27
Capacity of Approach (VPH)	815	1140	310	880
1987 Scheme I				
Demand Volume (VPH) pk-hr/8-hr	836/715	1161/727	314/309	1138/864
Green Phase Length (sec)	23	33	12	32
Capacity of Approach (VPH)	750	1076	285	1044
1987 Scheme II				
Demand Volume (VPH) pk-hr/8-hr	836/1244	1161/727	314/309	1079/852
Green Phase Length (sec)	24	33	12	31
Capacity of Approach (VPH)	783	1076	285	1011
2000 No Build				
Demand Volume (VPH) pk-hr/8-hr	885/738	1228/769	332/315	923/853
Green Phase Length (sec)	26	36	13	26
Capacity of Approach (VPH)	848	1174	308	848
2000 Preferred				
Demand Volume (VPH) pk-hr/8-hr	966/1337	1228/769	343/246	1442/935
Green Phase Length (sec)	23	30	12	35
Capacity of Approach (VPH)	750	979	285	1142
2000 Optional				
Demand Volume (VPH) pk-hr/8-hr	906/1334	1228/769	332/309	1314/930
Green Phase Length (sec)	21	29	11	31
Capacity of Approach (VPH)	686	946	261	1016

TABLE A-12. TRAFFIC INPUT DATA FOR THE INTERSECTION AT KEANY SQUARE FOR ALL ANALYSIS YEARS AND ALTERNATIVES WITH THE CENTRAL ARTERY RECONSTRUCTION.

General				
Approach	C'town Bridge	N. Washington	Commercial	Causeway St
Signal Length (sec)	100	100	100	100
Number of Lanes	3	3	2	3
1980 Baseline				
Demand Volume (VPH) pk-hr/8-hr	811/656	1124/704	295/279	781/779
Green Phase Length (sec)	23	33	12	22
Capacity of Approach (VPH)	750	1076	284	717
1987 No Build				
Demand Volume (VPH) pk-hr/8-hr	836/697	1161/727	314/297	872/806
Green Phase Length (sec)	25	35	13	27
Capacity of Approach (VPH)	815	1140	310	880
1987 Scheme I				
Demand Volume (VPH) pk-hr/8-hr	836/715	1161/727	314/309	1138/864
Green Phase Length (sec)	23	33	12	32
Capacity of Approach (VPH)	750	1076	285	1044
1987 Scheme II				
Demand Volume (VPH) pk-hr/8-hr	836/1244	1161/727	314/309	1079/852
Green Phase Length (sec)	24	33	12	31
Capacity of Approach (VPH)	783	1076	285	1011
2000 No Build				
Demand Volume (VPH) pk-hr/8-hr	885/740	1228/440	332/220	923/510
Green Phase Length (sec)	26/37	36/22	13/16	26/25
Capacity of Approach (VPH)	848/1210	1174/720	308/380	848/820
2000 Preferred				
Demand Volume (VPH) pk-hr/8-hr	966/1340	1228/440	343/220	1442/560
Green Phase Length (sec)	23/51	30/17	12/11	35/21
Capacity of Approach (VPH)	750/1660	979/550	285/260	1142/690
2000 Optional				
Demand Volume (VPH) pk-hr/8-hr	906/1330	1228/440	332/220	1314/560
Green Phase Length (sec)	21/51	29/17	11/11	31/21
Capacity of Approach (VPH)	686/1660	946/550	261/260	1016/690

TABLE A-13. TRAFFIC INPUT DATA FOR THE INTERSECTION OF MERRIMAC STREET AND NEW CHARDON STREET FOR ALL ANALYSIS YEARS AND ALTERNATIVES.

General			
Approach	Merrimac EB	Merrimac WB	New Chardo
Signal Length (sec)	100	100	100
Number of Lanes	2	3	5
1980 Baseline			
Demand Volume (VPH) pk-hr/8-hr	470/470	647/463	937/851
Green Phase Length (sec)	32	32	35
Capacity of Approach (VPH)	844	1160	1692
1987 No Build			
Demand Volume (VPH) pk-hr/8-hr	483/483	669/479	970/878
Green Phase Length (sec)	32	33	35
Capacity of Approach (VPH)	844	1077	1692
1987 Scheme I			
Demand Volume (VPH) pk-hr/8-hr	639/527	669/493	970/870
Green Phase Length (sec)	39	29	32
Capacity of Approach (VPH)	1028	1051	1547
1987 Scheme II			
Demand Volume (VPH) pk-hr/8-hr	603/556	669/492	970/870
Green Phase Length (sec)	37	25	28
Capacity of Approach (VPH)	975	906	1353
2000 No Build			
Demand Volume (VPH) pk-hr/8-hr	511/511	700/501	1031/934
Green Phase Length (sec)	32	32	36
Capacity of Approach (VPH)	844	1160	1740
2000 Preferred			
Demand Volume (VPH) pk-hr/8-hr	833/578	768/505	1055/919
Green Phase Length (sec)	42	28	29
Capacity of Approach (VPH)	1107	1015	1402
2000 Optional			
Demand Volume (VPH) pk-hr/8-hr	754/564	715/493	1040/916
Green Phase Length (sec)	41	28	31
Capacity of Approach (VPH)	1081	1015	1498

TABLE A-14. TRAFFIC INPUT DATA FOR THE INTERSECTION OF BLACKSTONE STREET AND NEW CHARDON STREET FOR ALL ANALYSIS YEARS AN ALTERNATIVES.

General			
Approach	N. Washington	Blackstone	Cross
Signal Length (sec)	100	100	100
Number of Lanes	2	2	2
1980 Baseline			
Demand Volume (VPH) pk-hr/8-hr	523/476	613/516	308/301
Green Phase Length (sec)	68	68	32
Capacity of Approach (VPH)	1792	1792	844
1987 No Build			
Demand Volume (VPH) pk-hr/8-hr	542/492	634/596	319/312
Green Phase Length (sec)	68	68	32
Capacity of Approach (VPH)	1792	1792	844
1987 Scheme I			
Demand Volume (VPH) pk-hr/8-hr	560/509	634/575	319/312
Green Phase Length (sec)	68	68	32
Capacity of Approach (VPH)	1792	1792	844
1987 Scheme II			
Demand Volume (VPH) pk-hr/8-hr	560/509	634/575	319/312
Green Phase Length (sec)	68	68	32
Capacity of Approach (VPH)	1792	1792	844
2000 No Build			
Demand Volume (VPH) pk-hr/8-hr	589/523	657/618	339/331
Green Phase Length (sec)	67	67	33
Capacity of Approach (VPH)	1766	1766	870
2000 Preferred			
Demand Volume (VPH) pk-hr/8-hr	589/674	674/588	363/331
Green Phase Length (sec)	66	66	34
Capacity of Approach (VPH)	1740	1740	896
2000 Optional			
Demand Volume (VPH) pk-hr/8-hr	589/674	657/584	345/331
Green Phase Length (sec)	68	68	33
Capacity of Approach (VPH)	1792	1792	870

TABLE A-15. TRAFFIC INPUT DATA FOR THE INTERSECTON OF SUDBURY STREET, CONGRESS STREET, AND MERRIMAC STREET FOR ALL ANALYSIS YEA AND ALTERNATIVES.

General			
Approach	Merrimac	Congress	Sudbur
Signal Length (sec)	100	100	100
Number of Lanes	3	2	3
1980 Baseline			
Demand Volume (VPH) pk-hr/8-hr	755/690	598/428	1102/9
Green Phase Length (sec)	52	52	48
Capacity of Approach (VPH)	1885	1371	1740
1987 No Build			
Demand Volume (VPH) pk-hr/8-hr	778/709	618/442	1141/1
Green Phase Length (sec)	52	52	47
Capacity of Approach (VPH)	1885	1373	1704
1987 Scheme I			
Demand Volume (VPH) pk-hr/8-hr	936/790	618/455	1141/1
Green Phase Length (sec)	56	56	44
Capacity of Approach (VPH)	2030	1478	1595
1987 Scheme II			
Demand Volume (VPH) pk-hr/8-hr	895/790	618/454	1141/1
Green Phase Length (sec)	55	55	45
Capacity of Approach (VPH)	1994	1452	1631
2000 No Build			
Demand Volume (VPH) pk-hr/8-hr	825/750	657/470	1191/1
Green Phase Length (sec)	51	51	49
Capacity of Approach (VPH)	1849	1346	1776
2000 Preferred			
Demand Volume (VPH) pk-hr/8-hr	1146/844	725/477	1191/1
Green Phase Length (sec)	60	60	42
Capacity of Approach (VPH)	2175	1582	1523
2000 Optional			
Demand Volume (VPH) pk-hr/8-hr	1068/844	664/458	1191/1
Green Phase Length (sec)	58	58	40
Capacity of Approach (VPH)	2103	1529	1450

Table A-6 shows the various parking parameters used in estimating emissions from the proposed parking areas for the Build Alternatives. These parking areas include the GSA garage, a 1000-car garage implemented in Phase I near the GSA lot (I-2), a 500-car garage for the Arena (I-3), a 1100-car garage for the hotel and retail space in the Preferred Alternative (II-6A), a 1400-car garage for the residential and office building in Optional Alternative (II-6B), a 1100-car garage for the residential parking in Preferred Alternative (II-7A), and a 100-car lot for the hospital in the Optional Alternative (II-7B).

Vehicle Speeds

Emission factors vary with average vehicle speed. The FTP compiles emission data at three average vehicle speeds corresponding to the three phases of engine operation (noncatalyst cold, catalyst hot, and catalyst cold). The weighted average speed for the whole cycle is about 20 mph. At speeds other than 20 mph, the FTP provides for adjustments.

The average vehicle (free flow) speeds that were used in the analysis vary with the averaging time periods, as shown below:

Time Period	Type of Facility	Average Speed, in mph
24-hr	Expressway	35
	Arterial	20
8-hr	Expressway	30
	Arterial	18
1-hr	Expressway	20
	Arterial	13

Credit for Inspection and Maintenance

The emission factors for future years vary according to whether there is an Inspection and Maintenance (I/M) program, and the nature of this I/M program. For the purpose of the North Station Analysis, it was assumed that the Massachusetts I/M program would be implemented by 1983, and that all light-duty vehicles and light-duty trucks would be impacted. It was further assumed that a mechanic training program would be in effect, and that the stringency level for the inspection would be 20%. The identification rate for Technology 4 vehicles was left at a national average default value of 50%.

2. ESTIMATING EMISSION FROM DIESEL LOCOMOTIVES

Emission factors as compiled in EPA's AP-42 document were used to estimate emissions from the diesel locomotives. These emission factors vary depending on the type of locomotives. For the GM F40PH locomotive that was used to represent the locomotive population in this analysis, the emission factors used are 4.1 grams per horsepower-hour (g/hp-hr) for carbon monoxide, 10 g/hp-hr for oxides of nitrogen, and 2.2 g/hp-hr for hydrocarbons.

The work equivalent in hp-hr that is needed to estimate emissions from a single locomotive per cycle is obtained by multiplying the rated 3000 hp for the GM F40PH locomotive by a load factor of about 6%. This load factor is based on averaged percentage rated power when the engine is at the idle throttle position, and on the assumed average idle time of about 20 minutes per cycle [1].

Peak-hour emission rates and 24-hr emissions inventories are obtained by multiplying the emissions per locomotive per cycle with the number of trains expected during the time period. On the basis of data from the MBTA [1], the peak-hour volume for 1980 was estimated at 22.5 train-moves, and for the 24-hr period it was 221 train-moves. For 1987, the peak-hr and 24-hr volumes used are respectively 45 and 234 train-moves; and in 2000, the corresponding volumes used are 51 and 242 train-moves.

3. DIFFUSION MODELING ANALYSIS

After the pollutants are discharged into the atmosphere by the various emission sources, the pollutants are transported by the prevailing wind and diluted through dispersion by atmospheric turbulence. The resulting pollutant concentration at any location in the study area is dictated by the rate of emission of the pollutant sources, the spatial distribution of the emission sources, and the meteorology variables.

3.1 Estimating CO Concentrations from Motor Vehicle Sources

Ambient CO concentrations caused by motor vehicles on the expressways, the arterials, and the parking facilties were estimated by the Federal Highway Administration CALINE 3 Model [7]. The various input elements of this model are described below.

Emission Rates

Emission rates for automobile sources are specified as emissions of CO per unit time per unit length of roadway. The emission rates on a given road segment in the vicinity of an intersection are accounted for as a two-component variable. The first is the free-flow or cruise emission rate. This rate is obtained by multiplying the free-flow emission factor by the traffic volume and the distance traveled by these vehicles in the time interval in question. The second component is called the excess emission rate and is made up of emissions from vehicles idling in a queue, waiting for a traffic light or at a stop sign, and from decelerating and accelerating vehicles coming into and out of the queue. Emissions from idling vehicles in a queue at an intersection, and from vehicles decelerating and accelerating, are estimated based on EPA's indirect source guidelines. The emissions associated with an accelerating or decelerating vehicle are a function of terminal vehicle free-flow speed and the rate of acceleration or deceleration. For this application, we followed the guideline's assumption of 2.5 mph/sec.

Spatial Distribution of Emission Sources and Receptor Locations

Layouts of the roads and parking facilities for the existing conditions and the future cases were used to determine location of the line sources that represent the emission sources from the motor vehicles. These layouts were also used to select receptor locations and to develop a common coordinate system by which emission sources and receptor locations could be input into the diffusion model mathematically. In the North Station analysis, we selected receptors at many different locations, including the Massachusetts Rehabilitation Hospital, the Charles River Park Apartments, the West End Project, the Charlesbank Playground, residences along North Washington Street, the North Station, and at a number of intersectons for which impact from the proposed project is anticipated. These receptors are shown in Fig. A.3. For any given wind direction, the reported concentration at each receptor is represented by the sum of contributions from all emission sources (i.e., roadway links) that are upwind of the receptor, and a background concentration.

Meterological Variables

The primary variables affecting the dispersion of CO are wind speed and direction, atmospheric stability, and the vertical thickness of the mixing layer.

The prevailing wind will dictate the general direction of movement of the CO emissions. High wind speed will promote transport and result in low ambient CO concentrations. To estimate potentially worst situations, we used a low wind speed of 1 m/sec in the 1-hr modeling analysis, and 3 m/sec in the 8-hr analysis. Sixteen wind directions, corresponding to each of the

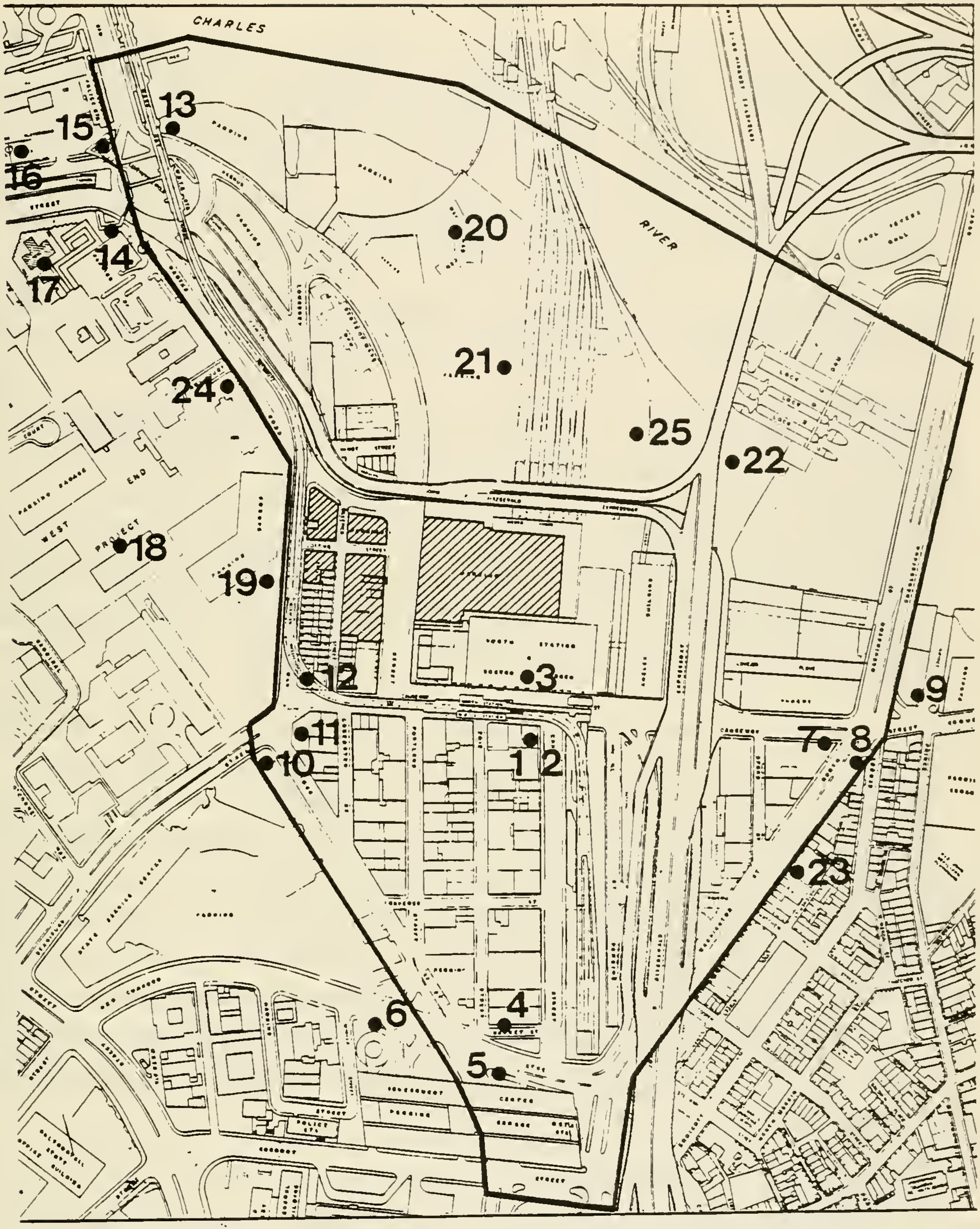

FIG. A.3. PROJECT AREA SHOWING LOCATIONS OF RECEPTORS USED IN THE MODELING ANALYSIS.

major compass directions (e.g., N, NNE, NE, etc.) were investigated, and the wind direction that resulted in the highest total concentration at a receptor was the direction chosen to estimate the maximum concentration. This maximum wind direction varied from receptor to receptor, from one averaging time to the next, and from one project alternative to another.

The stability of the atmosphere affects the dispersion of the mixing rate of CO (in an exhaust plume, for example) with the ambient air. This stability is determined by the vertical temperature gradient of the atmosphere. An unstable atmosphere will promote both vertical and horizontal mixing leading to lower concentrations. Coversely, a stable atmosphere will result in higher ambient concentrations. In the modeling analysis for North Station, a stable atmosphere (corresponding to a Pasquill classification of D stability) was assumed. This assumption is believed to be quite appropriate for an urban setting.

Another meteorology parameter affecting ambient concentrations is the vertical thickness of the mixing layer, also referred to as the mixing height. Higher mixing heights will result in a larger volume of air made available for dilution, resulting in lower ground level ambient concentrations. A review of mixing height data compiled by EPA [8] for the Boston area indicated that average mixing height for the morning is 400 m and for the afternoon is 1400 m. To reflect more severe, although less frequent, conditions associated with low-level temperature inversions, we assumed a mixing height of 100 m in the modeling analysis.

Background Concentrations

The background concentration is the level resulting from the sources other than the immediate adjacent streets, expressways, and parking facilities that were considered directly in the modeling analysis. Using techniques outlined in EPA's Hot Spot Guidelines [9], we assumed a 1-hr CO background of 4.4 parts per million (ppm) for 1980. Backgrounds levels for 1987 and 2000 were estimated using the rollback technique. Ratios of emission factors for a fleet for vehicles traveling at 20 mph were used to arrive at a 1.9 ppm background for 1987 and 1.2 ppm for 2000. Eight-hour background levels were established by applying a 0.75 persistence factor [10] to the background levels described above.

3.2 Estimating Nitrogen Dixide Concentrations from Diesel Locomotives

To estimate ambient nitrogen dioxide (NO_2) concentrations from vented diesel exhaust emissions, a "near-field" algorithm developed by Halitsky [2] was used. This algorithm is based on an empirically derived dilution factor, D, which related the ambient concentration of a receptor X to the concentration in the exhaust stack, X_e, or

$$X = \left(\frac{1}{D}\right) * X_e \qquad \text{(A.1)}$$

The concentration in the exhaust stack is related to the emission rate and the ventilation scenario. With ASHRAE's guideline of four air changes per hour, the X_e for 1987 with an estimated NO_2 emission rate of 7.5 g/sec, is 88.1 mg/m^3. In 2000, the emission rate increases to 8.5 g/sec, and the corresponding X_e was estimated at 99.8 mg/m^3. Under ventilation scenario No. 2, however, the X_e is fixed at 9.4 mg/m^3.

The dilution factor is a function of the arc distance from the exhaust stack to the receptor, s; the area of the exhaust stack opening, A_e; the source exit velocity, V_e; the approach wind velocity at stack height, V; and a building configuration factor M. This relationship is as follows:

$$D = 2.22 * M * \left[3.16 + \frac{0.1*s}{(A_e)^{1/2}}\right]^2 * \left(\frac{V}{V_e}\right) \qquad (A.2)$$

The range of values that were then used to estimate the various dilution factors are summarized below.

Arc distance, s. Because the exact location of the vents and other technical specifications relating to the ventilation of the covered section are not presently defined, a number of receptor locations were selected to represent the probable range of the impact. A total of six receptors were chosen, and these are grouped into three ranges of distances from the ventilation stacks. Within each range of distances, one receptor is located at rooftop level (to represent air intake of an adjacent building, for example), and the other is located at ground level (to represent concentration in the "cavity" of the exhaust plume). The three ranges of arc distances are 100 to 500 ft, 200 to 600 ft, and 800 to 1000 ft.

Area of exhaust opening, A_e: In the absence of more specific ventilation design factors, a 10-ft diameter opening was assumed. This dimension was arrived at based on a similar air-rights study for the South Station ventilation project [11]. The resulting area of the exhaust stack opening was estimated at 78.6 sq ft.

Source exit velocity: Based on the estimated ventilation requirements, and the range of capacities of typical exhaust fans, a total of 10 exhaust fans was assumed. For a ventilation rate of 1.8×10^5 cfm (corresponding to ventilation scenario No. 1), the source exit velocity was estimated at about 3.9 ft/sec. For ventilation scenario No. 2, the source exit velocities for 1987 and 2000 were estimated at 35.9 and 40.7 ft/sec, respectively.

Approach wind velocity, V: The National Weather Service normally summarizes wind data into a sector of discrete wind speed classes. The ranges for the two lowest speed classes are 0 to 3 knots (kt) and 4 to 6 kt. The median values of these two classes - 1.5 and 5 kts - were used to estimated the dilution factors.

Building configuration factor, M: This is another empirical factor to account for the effect of turbulent mixing in building values. For receptors that are located on rooftops of adjacent buildings, a value of 2.0 was assumed for M. For receptors that are located in the "cavity" of the exhaust plume, the ground value of M was 4.0.

Appendix O SERVICE ROAD AND GARAGE VENTILATION - BRIEF ANALYSIS

APPENDIX O

CE MAGUIRE, INC.
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January 7, 1983

Mr. John Tomasz
Project Engineer
Boston Redevelopment Authority
One City Hall Square
Boston, MA 02201

RE: BRA North Station Project
Service Road Feasibility Study
Tunnel Section - Ventilation

Dear Mr. Tomasz:

As requested, we have investigated the need for ventilation for the proposed Service Road from future widened Lomasney Way to Beverly Street especially within the tunnel section under the proposed Arena.

Even though the proposed Parking Garage (rear of GSA Building) will arcade over the Service Road, which is at grade, ventilation will not be required because the garage is planned to be a conventional, open-frame structure allowing air distribution with the northerly arcaded face being totally open except for supporting columns. This condition prevails from the widened Lomasney Way to the proposed Pedestrian Concourse.

From the Pedestrian Concourse to the easterly face of the new Arena the Service Road becomes depressed and totally enclosed. Generally the lower length limit for tunnels requiring ventilation is 400 to 500 feet with the tunnel section of the Service Road under the Arena/Pedestrian Concourse being approximately 450 feet long. However, due to conditions such as the heavy vehicle congestion after arena events and the structure interference (arcade of parking garage, expressway ramps, etc.) beyond the tunnel sections, we presently suggest that a ventilation system be provided, probably of a "semi-transverse" type. A semi-transverse system is where the exhaust (probably incorporated into the Arena parking garage exhaust system) is located near the center of the tunnel on one side (southerly in this case) and utilizes the tunnel portals as intakes.

Enclosed is the investigative report as prepared by our HVAC Department.

Very truly yours,

John J. Phillips
Project Manager
Environmental Engineering Division

Enclosure

cc: E. Owen Donnelly, Senior Project Coordinator
A. Landers, E. Moresco, R. Cunningham

THE MAGUIRE GROUP

Interoffice Correspondence

CEM No. 500.64

Date: January 7, 1983

To: John Phillips

From: E. Moresco

Subject: BRA North Station
Service Road and Garage Ventilation
Brief Analysis

1. The various areas where ventilation should be considered are as follows:

   a. The service road which is arcaded under the "overhead" parking garage. This portion of the road will be semi-enclosed, approximately 350 feet long.

      The overhead parking garage will be "open" type, (i.e., requiring no mechanical ventilation), with capacity for 1000 cars.

   b. The underground parking garage under the Arena with capacity for 500 cars.

   c. The tunnel or underground portion of the service road, with an approximate length of 450 feet.

2. Service road arcaded under the overhead garage

   If this area is "open" (i.e., there will be wall openings in the range of 30% to 40% of the total wall area), where air may circulate unimpeded, mechanical ventilation will not be required. (We are assuming such configuration.)

3. Underground parking garage

   Fully enclosed parking garages must be ventilated by Code. Per NFPA, the rate of ventilation shall be a minimum of 6 ACpH (Air Changes per Hour).

   Given the large volume of the two levels:

   2 x 121,000 sq.ft. x 8 ft. (high) = 1,936,000 cu.ft.,

   the amount of air required will be large, in the range of 200,000 CFM.

This amount of fresh air will have to be brought into the Garage from a point high aboveground level, to avoid the partially contaminated air at street level which will occur before and after events in the Arena. Conversely, a similar amount of air will have to be exahusted, again, to a point, as high as possible, to avoid compounding the potential congestion at street level.

The ventilation system should also be capable of removing smoke in case of fire within the garage confines.

The size of fresh air and exhaust duct shafts required for the Arena Garage alone will be in the vicinity of 130 to 150 sq.ft. each.

A mechanical (fan) room will have to be provided.

4. Service road, underground portion (450 ft. long, 2-way, 2 lanes each)

   a. Under normal, "no congestion" conditions on highways a length of 400 to 500 feet is the lower limit of tunnel's length where ventilation has to be considered.

      The proposed section, however, cannot be considered "normal" in the sense that it will be part of a congested area especially when sporting events take place in the Arena.

      Such congestion will reach its peak immediately after the events, where 1,500 vehicles from both Garages will try to find their way out of the complex, running mostly with engines idling, the worst possible condition of CO production by motor vehicles.

   b. Without going into a full scale analysis of all the possible ways in which a short road of this kind may be ventilated, we foresee the need for at least a "semi-transverse" type of ventilation.

      In any case, the standard accepted ventilation rates are: 100 CFM/ft. lane of tunnel. This, in turn, will signify air flow rates of the following magnitude:

      450 ft. x 4 lanes x 100 CFM = 180,000 CFM

      The exhaust should be discharged as high as possible to insure dispersion.

   c. Fresh Air: (1) On a "full-transverse" ventilation system, fresh air is supplied on one side of the roadway with grilles along its entire length and exhausted at the other side of the roadway (again, with grilles, along its entire length), providing cross-type ventilation.

As a consequence, it requires air conveying, concrete ducts, one at each side of the underground roadway. Fan rooms, electrical equipment and the duct "chimneys" are usually incorporated in a single building for both fresh air and exhaust air, generally at midpoint of the roadway.

Because of the short length of the tunnel, we consider such system unnecessarily expensive.

(2) A "semi-transverse" ventilation system does not require the supply and exhaust ducts on each side of the roadway; the ventilation equipment will consist only of the "exhaust" fans. The tunnel itself will be the air-conveying duct using the portals as fresh air intakes.

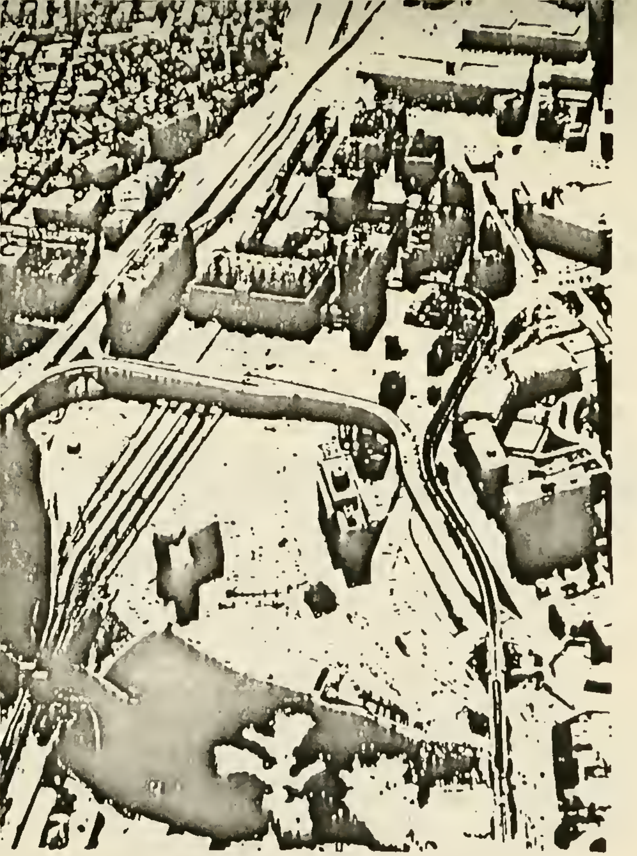
d. We estimate that given the conditions in the area

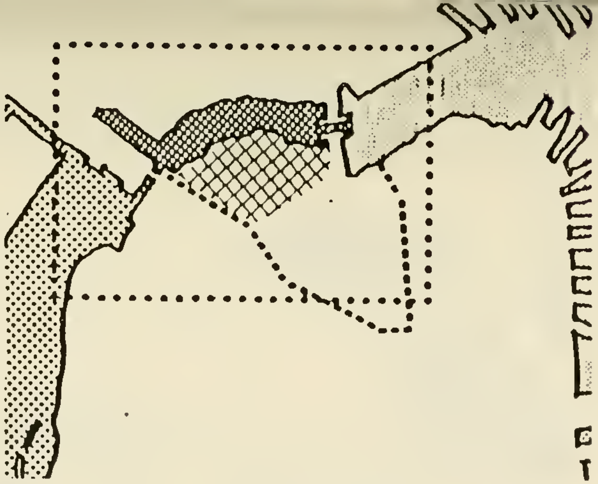
(1) A ventilation system should be provided for the underground roadway.

(2) We recommend that such system be a "semi-transverse" type of ventilation.

e. It would be quite convenient to integrate the ventilation system of the underground garage and that of the underground service road into a single mechanical equipment room. The exhaust air conduits could be combined into a common stack, of a combined capacity of (200,000 + 180,000) = 380,000 CFM.

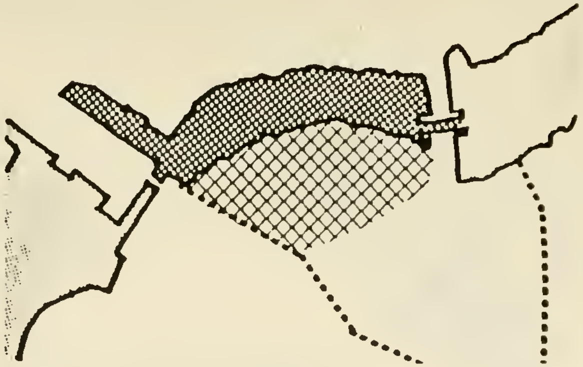
Appendix P NORTH STATION PROJECT URBAN DESIGN ALTERNATIVES





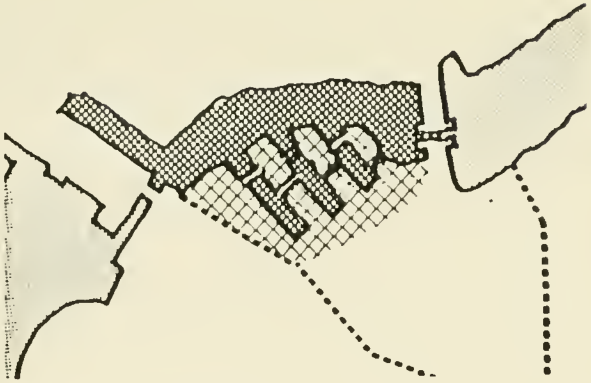
5.4 River's Edge

The nature of the Charles River has changed between the new Dam and the Museum of Science; it no longer belongs to the Harbor but rather is part of the urban river system which runs through Watertown, Cambridge, and Back Bay. While the river front abuts the Esplanade Park, it does not seem to be of the same character as the Esplanade but rather reflects the downtown mix of residential, commercial and office activity. The Charles River that passes North Station should combine qualities of promenade, linear green space, building edges and residential and small commercial activity. There are four land structuring scenarios for redefining the new River edge.



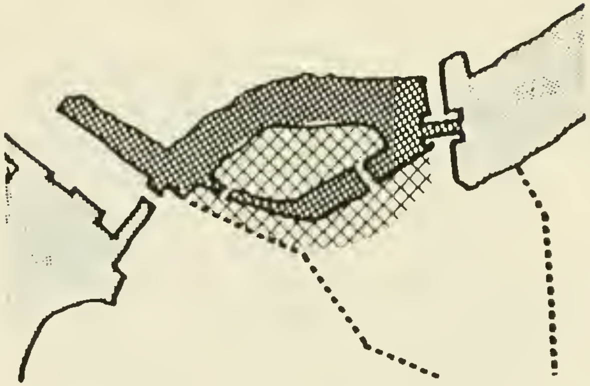
■ Land Extension

This scenario assumes little manipulation of the River's edge, relying upon open spaces and pedestrian parks to connect developed areas. While this approach may be the least expensive to implement, it does not take full advantage of the water's presence, except along the edge at the river bank.



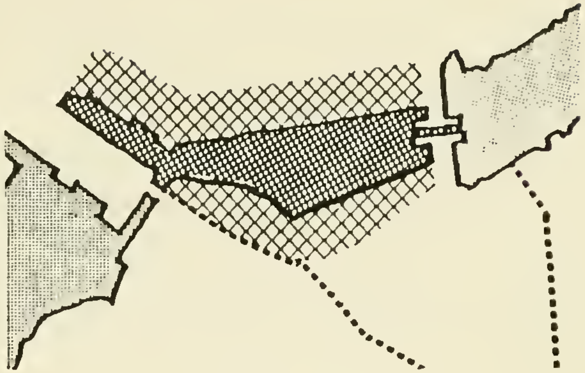
Piers and Canals

The water is brought into the site as a series of channels and bridges that intersect the area. More development area has the opportunity to relate to the water presence, establishing a one-of-a-kind environment in urban Boston. Walkways, buildings, and open space share a common water experience, as found in Amsterdam and Venice.



Island

A new island and channel of water are added to the Charles, just as the Storrow Lagoon was created by the Esplanade islands. The island is the destination of the path that begins at Faneuil Hall and Government Center, permitting pedestrians to join the urban river system going to the Esplanade and points west. The island's size permits development, open space, and public spaces to coexist on both sides of the channel.



Urban Basin

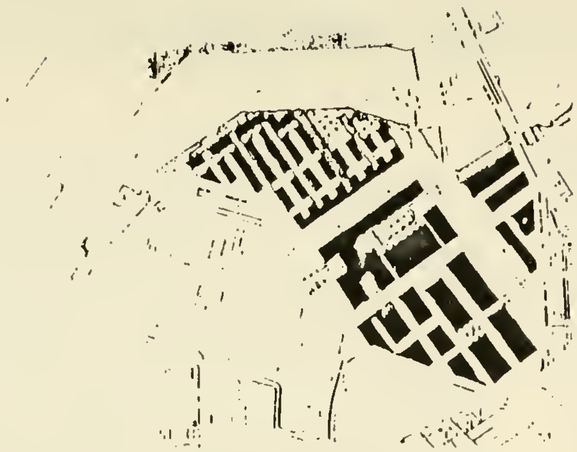
This approach redefines the Charles as a grand basin, bound on either side with urban activity, linear park spaces, and development back from the edges. New land is added to the north bank, permitting excellent views back to North Station and Boston proper. Improved boat movement between the new dam and the Museum of Science is an integral part of this scenario.

6.0

Alternative Strategies

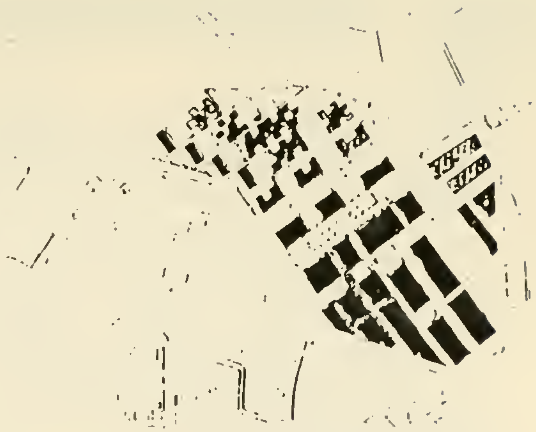
The following sketches depict five alternative strategies for developing the North Station Area. Each strategy implies different approaches toward land use, including location, quantities, massing and circulation. For comparison purposes, there is a single design scenario for each alternative (other design variations are possible for a particular alternative).

Development strategies are not schematic plans. They emphasize relationships of land use and movement rather than specific forms. Patterns are established as opposed to actual building locations. A hierarchy of pedestrian and automobile circulation is shown, not the specific walkways or roads.



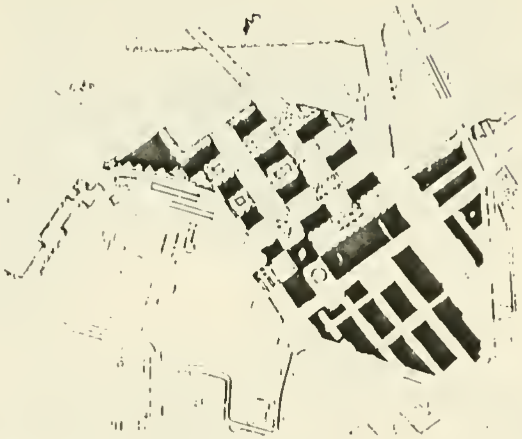
■ Back Bay Fabric

The three existing subdistricts of the North Station Area emerge as distinct entities with the "Back Bay Fabric" approach. The residential, office and commercial/wholesale uses are split among the River edge, Garden area, and Bulfinch Triangle. The Expressway ramp and Causeway Street act as dividing lines. The resulting pattern of development and pedestrian circulation also reinforces the different qualities of each subdistrict. Only a few pedestrian routes tie the three districts together. A neighborhood similar in scale to Back Bay continues the residential band that begins up river and extends to the new waterfront downtown.



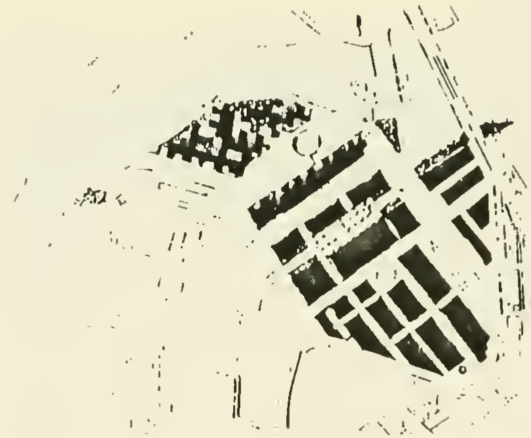
■ Towers in the Park

With the removal of the elevated Green Line structure, the River area can function as an extension of the West End development pattern, with residential towers located along Lomasney Way. Such a strategy also develops the water's edge near the new Dam as hotel and commercial uses, thus drawing visitors and residents to a focus on the River. The Garden area becomes a major retail center, leaving the Bulfinch Triangle as a specialized wholesale trade district (with small trade mart). The commercial pedestrian circulation might extend from the Garden to the River, with a major retail tenant replacing the hotel.



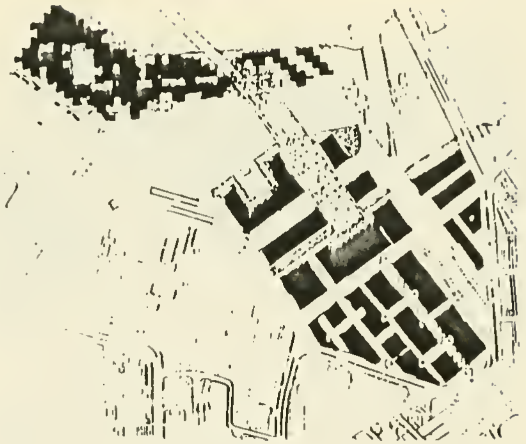
Piers and Canals

Water canals are used to define land uses and development parcels. At the same time, these water channels tie different functions together and create special walkways and ambience. Housing activity is located adjacent to the West End, while a hotel/office/commercial complex is situated near the new Dam, similar to Place Bonaventure in Montreal. A retail mall connects the River development to the Garden area consisting of office, hospital research, and parking uses. The commercial activities along the canal draw people from downtown through the entire North Station Area.



Mixed Use Island

An island is created in the Charles by cutting a channel of water into the site. The Island scenario encompasses a residential development along with open space, thus extending the Esplanade park system beyond the Museum of Science to Charlestown and the downtown waterfront. At the same time, the water channel takes on an urban quality with shops and a hotel along a new promenade. The Garden area is developed as retail and office uses, with the Bulfinch Triangle emphasizing a more mixed use orientation, including wholesale, exhibition, office, and retail uses.



Urban Basin

By creating a new residential development on the north side of the River and a hotel/mini-convention center on the south bank, a new Urban Basin is established that relates to the scale and activity of the River. This scenario exploits the water potential further than the other strategies by establishing water frontage as integral parts of development. While the advantages of excellent views and maximum water activity are apparent, the economic costs of massive land removal and the political coordination required between Boston and Cambridge must be taken into consideration.

Source: Moshe Safdie and Associates, Inc., A Development Plan for: North Station District, (1980).

Appendix Q SECTION 106 REVIEW LETTERS

1. North Station Urban Renewal Project
2. Green Line North Station Alternatives Study
3. Determination of Eligibility of Green Line Elevated Structure
4. Federal Office Building Site

APPENDIX Q-1

MASSACHUSETTS
HISTORICAL
COMMISSION

COMMONWEALTH OF MASSACHUSETT
Office of the Secretary of State

294 Washington Street
Boston, Massachusetts
02108
617-727-8470

MICHAEL JOSEPH CONNOLLY
Secretary of State

September 14, 1981

Richard Mertens
Environmental Review Officer
Boston Redevelopment Authority
1 City Hall Square
Boston, MA 02201

RE: North Station Urban Renewal
Project

Dear Mr. Mertens:

This office has reviewed the North Station Urban Renewal Project as described in your letter of July 10, 1981.

After careful review of this material, it has been determined that your proposal will not affect significant cultural, historical, or archaeological resources. This initial consultation to identify resources in the project area has been undertaken in accordance with 36CFR800, the Advisory Council Regulations for the Protection of Cultural Resources. Since no significant resources were identified in the vicinity of the proposal, no further compliance with Council Procedures is required.

If you should have any further questions, please contact Joe Orfant of my staff, Thank you for your cooperation.

Sincerely,

Patricia L. Weslowski, Executive Director
Massachusetts Historical Commission
State Historic Preservation Officer

JRO/pb

xc: Marcia Myers
R. Davis

APPENDIX Q-2

MASSACHUSETTS
HISTORICAL
COMMISSION

COMMONWEALTH OF MASSACHUSE
Office of the Secretary of State

294 Washington Street
Boston, Massachusetts
02108
617-727-8470

MICHAEL JOSEPH CONNOLLY
Secretary of State

April 23, 1981

Charles B. Steward, Environmental Coordinator
Massachusetts Bay Transportation Authority
50 High Street
Boston, MA 02110

Re: Green Line North Station Alternatives Study

Dear Mr. Steward:

Thank you for supplying the Massachusetts Historical Commission with information with your recent letter.

MHC staff have reviewed all proposed alternatives of the Green Line North Station Alternatives Study. MHC finds that this project will have no effect to the Bullfinch Triangle Area or the Charles River Basin Historic District. No further review in compliance with Section 106 of the National Historic Preservation Act of 1966 is required.

If you have any further questions, please feel free to call Joe Orfant of my staff.

Sincerely,

Patricia L Weslowski

Patricia L. Weslowski
Executive Director
Massachusetts Historical Commission
State Historic Preservation Officer

PLW/pb

xc: Joe Hough, Advisory Council

APPENDIX Q-3

ASSACHUSETTS
HISTORICAL
COMMISSION

COMMONWEALTH OF MASSACHUSETT
Office of the Secretary of State

294 Washington Street
Boston, Massachusetts
02108
617-727-8470

MICHAEL JOSEPH CONNOLLY
Secretary of State

January 28, 1981

Mr. Charles B. Steward
Environmental Coordinator
MBTA
50 High Street
Boston, MA 02110

Re: East Cambridge Extension

Dear Mr. Steward:

Thank you for providing this office with additional information regarding the East Cambridge Extension structure of the Green Line.

After review of the material regarding its construction, history and use, I find that it does not appear to meet the National Register Criteria for Evaluation. The Extension does not exhibit any unique, unusual or innovated structural or engineering features. It is not associated with significant events or personages other than broad associations with the transportation systems. The only feature of note is its use by trolley cars. However, this does not seem sufficient to warrant its inclusion in the Register. I understand that the MBTA retains original drawings for its construction, therefore, listing would not add to available knowledge. Finally, the structure appears an insignificant portion of elevated transit and not related to the extensive and significant elevated railroad developments of the previous century.

If you should have any questions, please contact Joe Orfant of my staff.

Sincerely,

Patricia L Weslowski

Patricia L. Weslowski
State Historic Preservation Officer
Executive Director
Massachusetts Historical Commission

PLW/pmb

xc: Marica Myers
Anthony Yudis

APPENDIX Q-4

**Advisory
Council On
Historic
Preservation**

1522 K Street NW.
Washington D.C.
20005

January 21, 1980

Ms. Beverly James
Historic Preservation Liaison
General Services Administration
Region 1
Boston, Massachusetts 02108

Dear Ms. James:

The amended Memorandum of Agreement for the new Federal Office Building in Boston, Massachusetts, has been ratified by the Chairman of the Council. This document constitutes the comments of the Council required by Section 106 of the National Historic Preservation Act and completes compliance with the Council's regulations, "Protection of Historic and Cultural Properties" (36 CFR Part 800). A copy of the Agreement is enclosed.

In accordance with Section 800.6(c)(2) and 800.9(e) of the regulations, a copy of this Memorandum of Agreement should be included in any environmental assessment or statement prepared for this undertaking to meet requirements of the National Environmental Policy Act and should be retained in your records as evidence of compliance with Section 106 of the National Historic Preservation Act.

The Council appreciates your cooperation in reaching a satisfactory resolution of this matter.

Sincerely,

Jordan E. Tannenbaum

Jordan E. Tannenbaum
Chief, Eastern Division
of Project Review

Enclosure
MOA

Advisory
Council On
Historic
Preservation

1522 K Street NW.
Washington D.C.
20005

AMENDMENT

MEMORANDUM OF AGREEMENT

WHEREAS, a Memorandum of Agreement among the General Services Administration (GSA), the Massachusetts State Historic Preservation Officer (SHPO) and the Advisory Council on Historic Preservation (Council) concerning the construction of a new Federal Office Building in Boston, Massachusetts, was ratified on September 20, 1979; and,

WHEREAS, GSA has now requested an Amendment to that Memorandum of Agreement to delete the Level III design competition; and,

WHEREAS, GSA, the Massachusetts SHPO, and the Council have consulted and agree that the purposes of the Memorandum of Agreement will not be affected by this amendment;

NOW, THEREFORE, it is mutually agreed that the attached stipulations "1", "2a", through "h" be substituted for those same stipulations in the original Memorandum of Agreement.

Robert M Utley (date) 12/5/79
Deputy Executive Director
Advisory Council on Historic Preservation

Beverly L. James (date) 12/17/79
Regional Historic Preservation Officer
General Services Administration - Region 1

Patricia L Weslowski (date) 12/17/
Massachusetts State Historic Preservation
Officer

(date) 1/14/80
Chairman
Advisory Council on Historic Preservation

Stipulations

1. Prior to final site selection, GSA will consult with the Massachusetts SHPO and the Council to determine what adverse effects selection of any one of the three sites currently under consideration might have on properties included in or eligible for inclusion in the National Register of Historic Places. GSA, the Massachusetts SHPO, and the Council shall then determine within 30 working days whether there are feasible and prudent alternative sites that avoid adverse effects. If GSA, the Massachusetts SHPO, and the Council agree within the 30 working day period on an alternative that will avoid the adverse effects, GSA shall proceed with the undertaking at that site, subject to any conditions the consulting parties may agree upon. If the consulting parties do not agree within the 30 working day period, GSA may proceed with site selection after which the consulting parties will, in accordance with Stipulation 2 below, consider alternatives for the building design to mitigate the adverse effects.

2. After final site selection but prior to start of building design, GSA, in consultation with the Massachusetts SHPO and the Council, will establish criteria for the building design which will include but not be limited to the following conditions.

   a. In consultation with the Massachusetts SHPO, GSA will conduct a cultural resources survey and assessment that will identify the project's impact on historic, architectural, cultural, and archeological resources and the effect of the proposed undertaking on those resources. The survey area will include the selected site and the project's impact area. This survey will be carried out in accordance with the Secretary of the Interior's guidelines (36 CFR Section 60.6) and 36 CFR Part 66, Appendix B "Guidelines for the Location and Identification of Historic Properties Containing Scientific, Prehistoric, Historic or Archeological Data," and Appendix C "Professional Qualifications."

   b. GSA will develop a pre-design program and criteria for the project design in consultation with the Council and the Massachusetts SHPO that will take into consideration the aforementioned resources. This program will assess the potential effect of the project on identified resources within the project's impact area and, if that effect is adverse, will evaluate alternatives that would avoid or mitigate the adverse effect. Upon completion of the predesign program but prior to GSA's initiating design, the Council may conduct a public information meeting in accordance with the Council's regulations, Section 800.6(b)(3).

c. The pre-design program will be submitted to the Council and the Massachusetts SHPO for concurrence. Within 15 calendar days of receipt of the program, the Council and the Massachusetts SHPO will submit their comments to GSA. If either the Council or the SHPO do not concur with the program, GSA will complete the Council commenting process pursuant to 36 CFR Part 800.

d. The Council and the Massachusetts SHPO will participate in GSA's design selection process as part of GSA's evaluation committee, and their comments will be considered by GSA's evaluation committee in their decision making.

e. After an Architectural/Engineering contract has been awarded for the project, design development will be done in consultation with the Council and the Massachusetts SHPO at the concepts and tentatives stages. Within 15 calendar days following their receipt of copies of the A/E's conceptual and tentative submissions, the Council and the SHPO will submit their comments thereon to GSA.

f. Final project design will be submitted to the Council and the Massachusetts SHPO for review, and within 21 calendar days of receipt thereof, the Council and the SHPO will submit their comments thereon to GSA. If either the Council or the SHPO do not concur, GSA will complete the Council commenting process pursuant to 36 CFR Part 800.

g. If the final project development calls for demolition of any architectural or cultural resources identified in the cultural resources survey, GSA will have those resources recorded to the standards of the Historic American Buildings Survey (HABS) so there will be a permanent record of their existence. GSA will first contact HABS (Heritage Conservation and Recreation Service, Department of the Interior, Washington, D. C. 20243) to determine the level of documentation required. All documentation must be accepted by HABS prior to demolition.

h. If the final project development calls for the destruction of archeological resources, those resources will be treated in accordance with a data recovery plan implemented in accordance with the Council's "Guidelines for Making 'Adverse Effect'

Advisory Council On Historic Preservation

1522 K Street, NW
Washington, DC 20005

June 18, 1980

Ms. Beverly James
Historic Preservation Liaison
General Services Administration
Region 1
John W. McCormack Post Office
and Courthouse
Boston, MA 02109

Dear Ms. James:

Pursuant to our meeting on May 7, 1980, regarding site selection for the proposed Boston Federal Office Building, it is our understanding that GSA is actively reconsidering the North Station as an alternative building site. We also understand that full evaluation of this site will be documented in the final environmental impact statement for the project.

Reconsideration of North Station increases the building site alternatives to four.

1. Tremont Site

2. Theatre District Site.

3. Church Green Site.

4. North Station Site.

Selection of any one of the sites may have a direct or secondary adverse effect on historic resources but, on the basis of the thorough consideration previously given alternative sites, we feel it would be unproductive to further explore sites which may avoid effects on historic resources, as agreed upon by ourselves and Pat Weslowski, Massachusetts State Historic Preservation Officer, at the May 7 meeting. After evaluation of the alternative sites, it is our opinion that construction on the North Station site, which will not require demolition of any buildings onsite that may be eligible for inclusion in the National Register of Historic Places, would be the only alternative that would avoid such adverse effects and thus may be the preferred alternative. It is our understanding though that GSA is requiring the removal of the Green Line El along Causeway Street as a condition of its selection of this site. This condition would constitute an adverse effect on the El, if it is determined eligible for inclusion in the National Register. In addition the project design would have to take into consideration its affect on the Bulfinch Triangle Historic District, directly adjacent to the site.

Selection of the Theatre District site may also avoid direct adverse effects on historic resources but must take into consideration resources directly adjacent to the site. As discussed in our May 7 meeting selection of either the Tremont site or Church Green site, for a development program that calls for site clearance, would have an adverse effect on properties included in the National Register and accordingly neither of these sites should be chosen unless there are no prudent or feasible alternatives. We are of the opinion though that existing buildings on both of these sites could be adaptively reused as part of the proposed Federal Office Building rather than demolished. This reuse alternative should be throughly explored.

If you have any questions regarding this please call John Cullinane at FTS-254-3974.

Sincerely,

Jordan E. Tannenbaum

Jordan E. Tannenbaum
Chief, Eastern Division of
Project Review

Appendix R TIDELANDS TITLE/RIGHTS OF PUBLIC ACCESS

APPENDIX R

Tidelands Title/Rights of Public Access

Although much of the land lying between Causeway Street and the Charles River presently is owned by various agencies of the Commonwealth,[1] whether the actual title to all of this land remains with the Commonwealth is questionable. At the time of the settlement of Boston, the tidelands, or flats (that land lying between the high water mark and the low water mark) were held a public trust by the English Crown, claimed by right of discovery, which title subsequently was passed by the Charter of Charles I to the Governor and Company of the Massachusetts Bay.[2] Generally, by the common law of England, ownership of upland parcels extended seaward only to the line of high water; the earliest grants of the Colony bounding on tide waters, therefore, were to the high water line only and not below it. The Colonial Ordinance of 1647, however, took the flats out of the public domain and granted ownership and rights to them to the immediately adjacent littoral owners, subject only to the public rights of fishing, fowling, and navigation,[3] which interests are now the only public trust rights in the flats. With respect to the submerged lands (the lands seaward of the low water mark) title remained with the government of the Colony and, following the Revolution, with the Commonwealth, likewise in trust for the benefit of the public.

In the case of the North Station area, the situation appears to be, to some extent, somewhat different. On the 31st of July (then known as the fifth month), 1643, the town of Boston granted to Henry Simonds and others "all that Cove (already bounded) on the norwest side of the Causey leading toward Charleton, with all the salt marish bordering thereupon round about, not Formerly granted to any other..., to have and enjoy the sayd cove and marish to them and their heyres and assignes for ever."[4] This grant consisted of the North Cove (the present-day Bulfinch Triangle area) as well as the narrow island ("causey") that separated the cove from the river beyond and the flats and salt marsh outside the "causey", the low water mark lying below the mouth of the cove. Since the alignment of Causeway Street generally follows that of the former "causey" (which Simonds and his partners - known as the Mill Pond proprietors - turned into a mill dam), the flats outside this dam would include much of Sub-area I of the North Station project area and a substantial part of Sub-area II as well. (That this grant did, in fact, include the flats outside the mill dam also was evidenced by a 1735 deed from the Mill Pond proprietors to a Waldo and Cooke.) Moreover, in 1807, the town of Boston signed an indenture with the successors of the Mill Pond proprietors - the Boston Mill Corporation - in which the original grant was referred to as embracing the flats on both sides of the dam and in which the town released to the Corporation all rights and interests of the town in the mill pond and in the flats on the outside of the dam. The ownership of these flats was further substantiated by the Massachusetts Supreme Court in Rust v. Boston Mill Corporation in 1828.[5]

Further evidence of private ownership of the flats is found in many 19th century deeds granting parcels of land to the railroads, which contained such language as "to the low water line" or "all the flats belonging to the grantee".

Notwithstanding, as noted above, the public in general does have expressly reserved rights of navigation, fishing, and fowling in privately-held shorelands. Known as the public trust doctrine, these rights are based on the common-law concept that the public is entitled to use tidal water irrespective of whether the underlying lands are publicly or privately owned. However, the Massachusetts courts have construed the public trust in tidelands rather narrowly, and subordinate to the rights of the owner of the flats. For example, cases have held that private upland owners may fill or build within tidelands even though this restricts the public's use to some extent.[6] The judicial rationale is that the Ordinance of 1647, which modified the Ordinance of 1641, "is properly construed as granting the benefitted owners a fee (title) in the seashore to the extent described and subject to the public rights reserved."[7]

With respect to public access rights, the Commonwealth's Supreme Judicial Court likewise has been reluctant to approve greater public access to the shoreland.[8] In 1974, the justices were asked for an advisory opinion of a bill (H.481) recognizing "a public on-foot free right-of-passage" along the shore. All but one of the justices concluded that the proposed law would violate both Federal and State constitutional provisions requiring payment of fair compensation when private property is taken for a public purpose.[9] The justices stated that "on-foot right-of-passage is not...related to the rights of fishing, fowling, and navigation reserved to the public by the colonial ordinance."[10] "The rights of the public...have...been strictly confined to these well defined areas..."[11] Further, they declared "we are unable to find any authority that the rights of the public include the right to walk on the beach."[12]

In the North Station area, throughout the first half of the 19th century, the Massachusetts Legislature passed a multitude of statutes granting rights-of-way and bridge rights over the Charles River to the railroads entering Boston from the north, a license authority that subsequently was given to the Board of Harbor Commissioners and their successors. The public purpose of these legistative acts was the promotion of commerce. Consistent with the reserved rights of navigation, these grants required that the convenient passage of vessels in the Charles River not be hindered and that suitable draws be provided on any bridges constructed. In 1869, the Legislature declared that all "authority or license" thereafter granted to build on, fill, or enclose tidelands was to be "revocable at any time, at the discretion of the legislature".[13] Prior to this date, the courts have held that such acts of the Legislature operated as grants and not as mere revocable licenses. This issue was first addressed in Fitchburg R.R. v. Boston & Me. R.R., 3 Cush. 58, 87 (1849) and was subsequently upheld in Bradford v. McQuesten, 182 Mass. 80, 81 (1902) and most recently in Boston Waterfront Development Corporation v. Commonwealth, 393 N.E. 2d 356 (1979), 378 Mass. 629. However, the courts have also held that although the grantee has title in fee simple, such title is subject to a condition subsequent that it be used for the public purpose for which it was granted (a holding likewise affirmed in the Boston Waterfront case). In essence, then, the tidelands are subject to the same public trust in which the Commonwealth originally held them, and they may be used only for a purpose approved by the Legislature as a public use. Thus, although such lands may be granted to private owners for private use, there must be an overall public benefit of the private use.

In the North Station area, the approval of the Urban Renewal Plan by the Commonwealth declared the public benefits of the project and its proposals. Therefore, so long as the project area is used in conformance with the Renewal Plan, the Commonwealth has not abdicated its trust over the property that originally was tidelands.

Parenthetically, it should be noted that, in an attempt to explore the limits of the Legislature's authority relative to the public's rights in the tidelands, two bills (House 658 and Senate 1001) were filed early in the 1981 Legislative Session. Both bills provided for the extinguishment of the public's interest in those legally-filled tidelands within the City of Boston lying landward of a specified line (defined as the "1980 Line") drawn along certain major Boston streets.[14] In addition, the Senate bill provided for an administrative procedure for the extinguishment of the public trust interests in legally-filled tidelands lying seaward of the 1980 Line.

In response to questions submitted by the Senate regarding the constitutionality of certain provisions in the bills, the Supreme Judicial Court rendered a opinion, contained in S.2252 and S.2253 issued June 18, 1981, in which the Court declared that the Legislature did have the authority to transfer or relinquish the public trust interests in tidelands (including submerged lands), provided that a valid public purpose was thereby served.[15] The "condition subsequent" that the land be used for the public purpose for which it was granted could be eliminated by the Legislature, although the new use still must continue to serve a public purpose. Furthermore, the Court noted that the legislative authority to extinguish the public trust interests could be delegated to the Executive branch, provided adequate guidelines were drafted (both bills gave this power to the Executive Office of Environmental Affairs).

While the Court left unanswered the question of whether the public purposes listed in the bills served the requirements of a proper public purpose for which the public trust interest in tidelands lying seaward of the 1980 Line could be extinguished,[16] the Justices did conclude that for former flats and submerged lands lying landward of the 1980 Line a proper public purpose had been declared as the basis for extinguishing the public trust rights and that it was substantially in the public interest that such land be free from any claims of public trust and any other vestigial interest of the Commonwealth.

Footnotes

1. Nearly all of this land has been acquired by the Commonwealth from private parties during this century.

2. 1 Mass. Col. Rec. 3, Anc. Chart. 5.

3. The actions of this Ordinance and the titles acquired thereunder were confirmed by the Province Charter of 1691 and later by the Massachusetts Constitution (Art. VI of Ch. VI of Part the Second).

4. Second Report of the Record Commissioners of the City of Boston, Containing the Boston Records, 1634-1660 and the Book of Possessions, 2nd Edition, Boston, Rockwell & Churchill, City Printers, 1881, p. 74. That the town of Boston had the right to grant this land is unclear, but presumably resulted from the division of Colony lands, for the purpose of the building of towns, agreed upon in England shortly after the Massachusetts Bay Company obtained its Charter (19 March 1627-28). The only act of incorporation which Boston had under this Charter apparently was an order of the Court of Assistants, held at Charlestown on 7 September 1630, that "Trimountain shall be called Boston". During the early colonial period, there was no sharply defined line separating the powers which a town and the colony might respectively exercise. (Commonwealth v. Roxbury, 9 Gray 451, note at 510). Nonetheless, it has been recognized by the Judiciary that towns established under the authority of the General Court of the colony did become owners of all the land and water within their boundaries, with full power to grant any portion of either, except such as were held in trust for a public use or purpose (Berry v. Raddin, 11 Allen 577, 579-80 (1886)). In addition, existing records of the town of Boston (which date only from September 1634) show that from that time the town, through a committee chosen in the general town meeting, freely exercised the powers of granting land within the town (Boston v. Richardson, 13 Allen 146, 150 (1886)). It is also noted that the General Court (on 3rd March, 1635-6) did order that the freemen of every town "should have the power to dispose of their own lands and woods, to grant lots...." (The Book of General Laws and Libertyes 147 (1672), 1 Mass. Col. Rec. 172).

5. 6 Pickering 158. This case involved a dispute over the ownership of the flats between a Jacob P. Rust, who claimed possession by virtue of the Colonial Ordinance of 1641-47 by tracing title prior to 1643, and the aforementioned Boston Mill Corporation, which claimed title based on the grant of 1643. The Court found for the Corporation.

6. The courts have consistently held that "a littoral owner may build on his tidal land so as to exclude the public completely as long as he does not unreasonably interfere with navigation". (Opinion of the Justices, 365 Mass. 681, 687, 313 N.E. 2d 561, 566 (1974)). This apparent anomaly of the rights of property in the seashore (which is not a recent novelty in the law but an old and recognized principle) was established in Austin v. Carter) (1 Tyng 231, 232 (1804)), where the Court held that"... although it is true that... all the inhabitants of the commonwealth, had the right to pass and repass on the waters so long as the owner of the adjoining land leaves them open and unobstructed, yet the owner of the adjoining

land may, whensoever he pleases, enclose, build, and obstruct to low-water-mark, and exclude all mankind." Later cases (e.g., Drake v. Curtis, 1 Cush. 395, 413 (1848); Weston v. Sampson, 8 Cush. 347, 355 (1851)) also have emphasized the point that, while the owner of the flats may build upon or enclose them to the exclusion of the public, until a structure is erected or the flats are so enclosed, the public rights remain vested. "So long as the tide ebbs and flows over them, they so far retain their original character and remain public". (Weston v. Sampson, supra, at 354).

7. Opinion of the Justices, supra, 365 Mass. at 685; 313 N.E. 2d at 566. The Ordinance of 1647 amended the prior law which limited private upland ownership to the line of high water. As published in 1649, the Ordinance provided in part:

> ...It is declared that in all creeks, coves and other places, about and upon salt water where the Sea ebs and flows, the Proprietor of the land adjoyning shall have proprietie to the low water mark where the Sea doth not ebb above a hundred rods, and not more wheresoever it ebs farther...Provided that such Proprietor shall not by this libertie, have power to stop or hinder the passage of boats or other vessels in, or through any sea, creeks, or coves to other mens houses or lands. (The Book of General Laws and Libertyes 50 (1649)).

8. The discussion following is found in Graber, Peter H.F., "The Law of the Coast in a Clamshell, Part VI: The Massachusetts Approach", Shore and Beach, January 1982, pp 15-16, 18.

9. Opinion of the Justices, supra, 365 Mass. at 690-692, 694; 313 N.E. 2d at 568-569, 571.

10. Id. 365 Mass. at 686; 313 N.E. 2d at 566.

11. Id. 365 Mass. at 688; 313 N.E. 2d at 567.

12. Id. 365 Mass. at 687; 313 N.E. 2d at 567.

13. Chapter 432, Acts of 1869, §1. Subsequently, in more recent times, many of these licenses were declared irrevocable by the Legislature. For example, Chapter 691 of the Acts of 1962 made irrevocable License No. 1177A of the Massachusetts DPW to the Boston and Maine Railroad to build and maintain drawbridges over the Charles and to fill solid in the Charles.

14. In the North Station area, these streets included Charles Street, the Fitzgerald Expressway access ramp, and the Fitzgerald Expressway (Central Artery); these boundaries included all of Sub-area I of the project area.

15. This is consistent with an earlier decision of the Court, which found that the Commonwealth could "...by way of grant pass its interests (both its proprietary rights and the public interest held in trust) by act of the Legislature in lands that are below extreme low water mark, and

which when filled by the grantee will extinguish the rights of use by the public." (Commonwealth v. Boston Terminal Co., 185 Mass. 281, 283-284 (1904)).

16. These public purposes included "...any commercial, industrial, business, residential conservation or other purposes for which any real estate has been, could now be, or may in the future be lawfully used... provided, however, that public trust rights are preserved and protected."

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